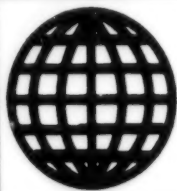


JPRS-JST-94-032  
26 September 1994



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# ***JPRS Report***

# **Science & Technology**

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***Japan***

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# Science & Technology Japan

JPRS-JST-94-032

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26 September 1994

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## Study on Weaving Method/Strength Analysis for 3-Dimensional Textile Structural Composites

43070201A Tokyo MITSUBISHI HEAVY INDUSTRIES LTD. TECHNICAL REVIEW in English Jun 94 pp 87-91

[Article by Tetsuya Yamamoto, Shigeru Nishiyama, and Kanehiro Nagai of the Nagoya Aerospace Systems Works]

[Text] Three-dimensional fiber (3-D fabric) reinforced composites are superior in interlaminar strength and impact strength, so they are expected to be used for various members of aerospace structures. In this paper, the continuous weaving method for 5-axis 3-D fabric using an original weaving loom, and an efficient and high-accuracy strength analysis method based on micro-mechanical analysis are described. As a result of those studies, one of the method of continuous weaving for 5-axis 3-D fabric was found out, and the validity of present strength analysis method is confirmed by comparing between analytical and experimental results for OHT (Open Hole Tension) test specimen.

### 1. Introduction

Compared with duralumin, the resin matrix composites ensure the structure equivalent in strength and 20 percent lighter in weight, and are, therefore, practically used in the field of aerospace as the structural material. The prepreg materials that the resin impregnated into the woven fabric or yarn arranged in unidirectional have conventionally been used as the material of resin matrix composites. The prepreg materials are then cut off at desired fiber angle and into required shape, and several such pieces are then laminated and solidified to manufacture the products. Piles are being bonded interlaminarily with resin alone, the laminated composites cause delamination and have their strength remarkably deteriorated when a load exceeding the interlaminar bonding force is applied in the direction of lamination or when a foreign object collides to the surface of the laminates.

Hence, research and development were made on the three-dimensional composites obtained by three-dimensional arrangement of the reinforced fiber in the direction of required strength thereby making the fiber proof against out-of-plane load or impact to the surface (Figs. 1 and 2).

Described below are the results of research and development on the continuous weaving technology of five-axis three-dimensional fabric and the strength analysis technology of the 3-D composites.

### 2. Weaving method

Depending on the application, load condition, shape, etc., various weaving methods are being studied for the 3-D fabric, the textile structural reinforcement for 3-D composites.<sup>(1)(2)</sup> Mitsubishi Heavy Industries, Ltd. (MHI) also has studied the weaving method of joints where multi-axis load is exerted,<sup>(3)</sup> engine fan blades

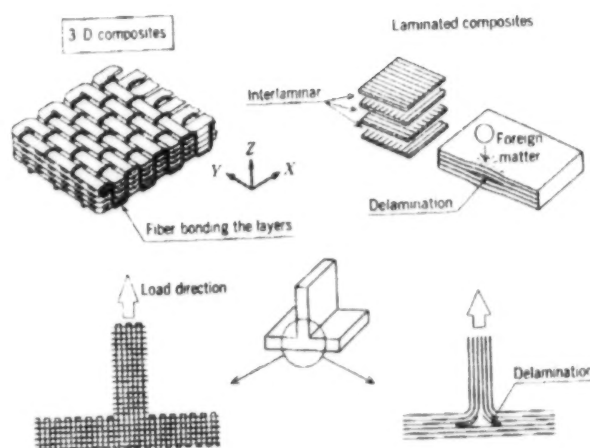


Figure 1. 3-D Composites. The 3-D composites do not cause delamination because of the fiber bonding the layers.

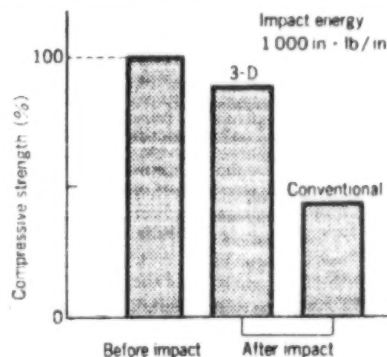


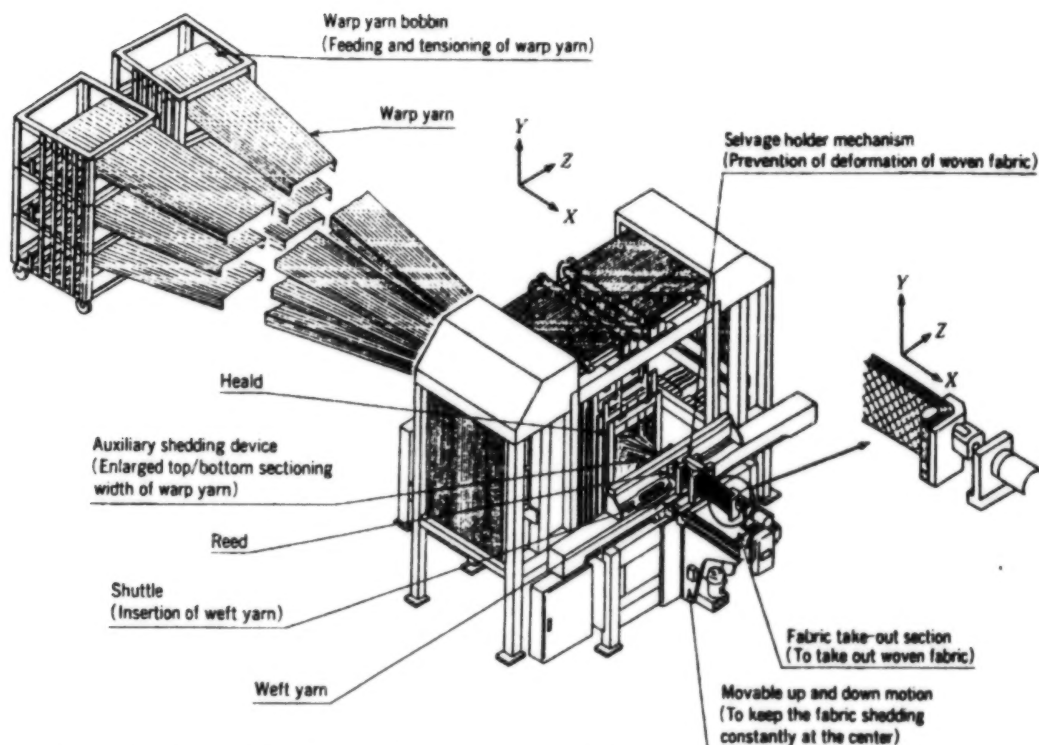
Figure 2. Compressive Strength After Impact. The 3-D composites are superior to the conventional laminated composites in terms of compressive strength after impact.

with complicated shapes and impact damage resistance is required, etc. This weaving method allowed greater freedom of fiber arrangement and enabled complicated shape weaving. However, it was not suitable for weaving large-size products, and it took quite a long time for weaving. If this problem is solved, and the 3-D fabrics, used for large-area and large-size parts of aircraft such as fuselage, outer skin of main wing required the strength after impact, are woven at a low cost, the aircraft weight can be further reduced. Therefore research was conducted on the continuous weaving method for 5-axis 3-D fabric (in-plane: four-axis, thickness direction: one-axis) applicable to the large-size parts, etc.

#### 2.1 The loom for 5-axis 3-D fabric (3-D loom)

The general shuttle or rapier looms, used for weaving fabric for fiber reinforced composites, are the machines used mainly for weaving two-axis fabric, and have been





**Figure 3. Weaving Loom for 3-D Fabric.** The weaving loom was developed and provided with unique mechanism to enable multi-axis weaving.

difficult to weave 5-axis 3-D fabric. Hence, a 3-D loom based on the mechanism of shuttle loom was manufactured to study the weaving method for 5-axis 3-D fabric. The outline of the 3-D loom is shown in Fig. 3. The loom has a larger number of healds (NOTE: The part that arranges the wires with holes for threading warp yarn (mails) to provide shedding motion to the warp yarn passed through the mail.) for shedding the warp yarn, and is equipped with an auxiliary shedding device to compensate for the reduction in shedding angle. Moreover, in order to prevent the fabric from getting crushed by the tension of the warp yarn, the selvage holders are installed at the top and bottom of the fabric, while the movable up and down motion device is installed to keep constant the position between shedding portion and passage of weft yarn insertion.

The basic principle of 3-D fabric weaving is as follows. In Fig. 3 the warp yarn arranged in four-axis directions in  $XY$  planes is supplied from the tension-controlled warp bobbins, whereas the weft yarn inserted into  $Z$  direction is supplied from the shuttle. The warp yarn passes through heald and reed (NOTE: (1) The part that arranges and guides the warp yarns with specified space interval; (2) The part that presses the weft yarn, inserted into the warp shedding against the fabric.) and is fixed to the fabric takeout device. Fig. 4 shows the weaving mechanics of the fabric actually woven by using this loom, with the Figure on the left indicating the healds all

in upward motion causing all warp yarns to move up. The figure at the center shows the warp yarns (1) and (2) lowered down by using healds to form a shedding where the weft yarn A is inserted by moving the shuttle right (left). The figure on right shows the warp yarns (3), (4) and (5) lowered down to form shedding over the weft yarn A where the weft yarn B is inserted. Next, the warp yarns (6), (7) and (8) are lowered down and the weft yarn is inserted. These processes are successively repeated with the beat-up and take-up carried out at required positions to weave the 5-axis 3-D fabric.

## 2.2 Weaving experiment

The precise weaving method by using carbon fiber was duly studied with an aim at weaving the 3-D fabric with in-plane quasi-equal characteristics.

The kinds of carbon fiber in use were basically 12K (12000 filaments), with the fiber used for warp yarn forming  $\pm 45^\circ$  only being 6K (6000 filaments) in order to adjust the fiber arrangement ratio. The threading of warp yarn to the heald and reed was carried out carefully in order to prevent the fluff from raising as the filaments get cut off due to the rubbing of fibers, and take a cotton-like form. The heald driving sequence was determined on the basis of the structural fiber architecture.

In the meantime a computerized weaving simulation was carried out in order to evaluate the internal fiber arrangement state.

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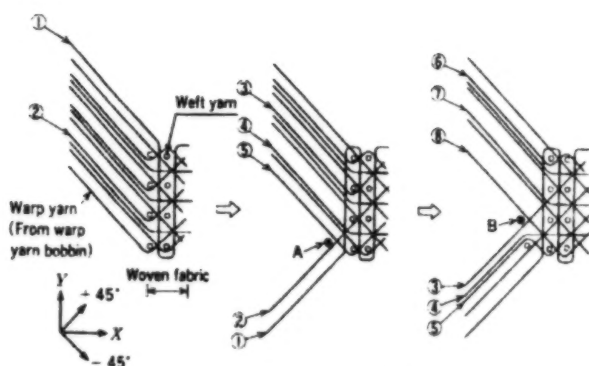


Figure 4. Weaving Mechanics of 3-D Fabric. The process of 3-D fabric being woven.

Experiment was made for weaving the 3-dimensional fabric based on the weaving conditions so far studied.

During the experiment the fiber surface was coated in order to evaluate the influence of the sizing agent, providing resistive force against rubbing, on the fabric quality.

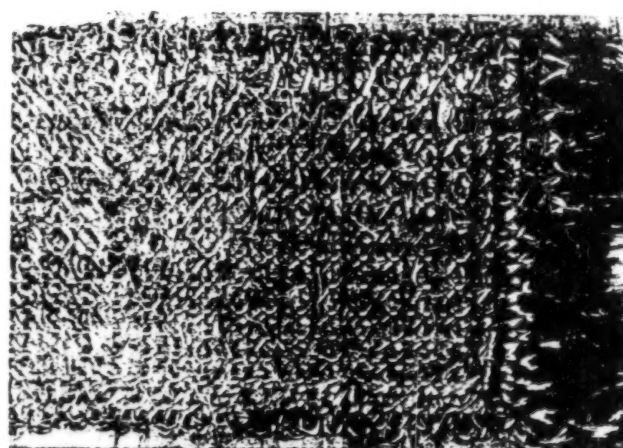
The woven 3-D fabric was then subjected to resin transfer molding, and the molded product to sectional observation to evaluate the fiber arrangement condition.

The product was then separated into component fibers and the weight was measured to confirm the fiber arrangement ratio. As for the 3-D composite fabrication the resin film infusion method was adopted. This method is suitable for the molding of large-size products of 3-D fabric with comparatively simple shape.<sup>(4)</sup>

### 2.3 Result of weaving

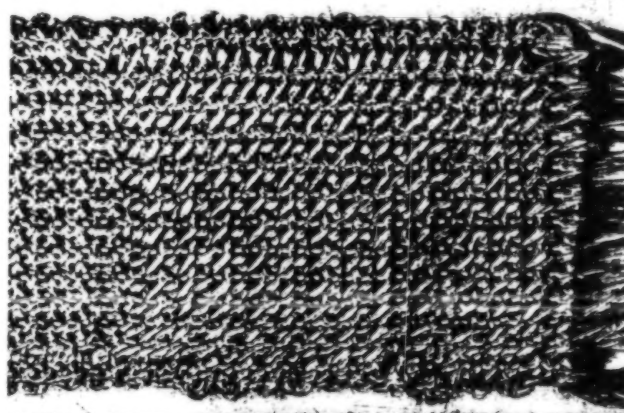
Fig. 5 shows the appearance of the woven 3-D fabric, with the fabric at the top woven by using solid epoxy sizing agent and the fabric at the bottom by using liquid glycol sizing agent, both at ordinary temperature. The fabric woven by using glycol sizing agent evidently shows less fluff and higher quality than the other fabric. This may be attributed to the difference in lubricity when the fiber gets rubbed by heald and reed, indicating that selection of the sizing agent is very important to improve the quality of 3-D fabric with complicated fiber arrangement.

The internal fiber arrangement condition was confirmed by means of the computer simulation drawing the structural fiber architecture based on the condition of warp yarn threading to the loom and the drive sequence. As a result, the drawn structural fiber architecture corresponded well to the designed structural fiber architecture set as the weaving object, and the fiber arrangement condition was confirmed to be excellent.



1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8

(a) Solid epoxy sizing agent used at ordinary temp.



5 6 7 8 9 1 2 3 4 5 6 7 8 9

(b) Liquid glycol sizing agent used at ordinary temp.

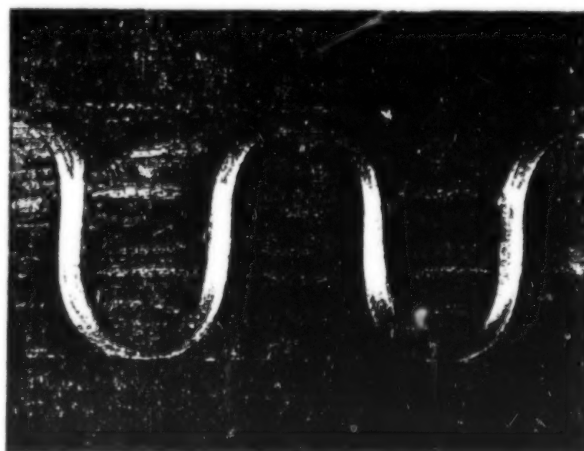
**Figure 5. 3-D Woven Fabric. Sizing agent largely affects the fabric quality.**

Fig. 6 shows the cross section of 3-D composite in the direction of thickness, and Table 1 the measured data of fiber arrangement ratio.

**Table 1. Fiber Ratio in Each Direction (Unit: %)**

	X	Y	Z	U	V
Measured value	21.2	21.2	10.8	23.4	23.4
Calculated value	21.0	21.0	13.4	22.3	22.3

As a result of cross section observation, the fiber arrangement condition of weft yarn was also found to be excellent, and the in-plane ( $X, Y, \pm 45^\circ$ ) fiber arrangement ratio was confirmed to conform to the set object. The discrepancy in  $Z$ -direction yarn ratio was attributed to the reduction in weft yarn consumption in  $Z$ -direction, equivalent to the reduction in thickness, owing to the weaving density of 39.3 percent after weaving

**Figure 6. Cross Section of 3-D Composite. Weft yarn arrangement condition in the thickness direction.**

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which was higher than the estimated calculation value of 32.1 percent. Moreover, the estimated calculation of weaving density was based on the assumption that the yarn cross section was cylindrical in shape. It is necessary to improve the accuracy of calculation by assuming the yarn cross section for each structural fiber to be circular, rectangular or cylindrical on the basis of the accumulated data of yarn cross section.

### 3. Strength analysis method

The three-dimensional composite is a kind of tailored material capable of providing arbitrary material characteristics by appropriately determining the fiber weaving architecture and orientation ratio. However, it is indispensable to establish an analytical technology in order to design high-performance products by making use of these outstanding characteristics. In particular, the strength analysis method is a basic and important technology to apply this material to various kinds of products.

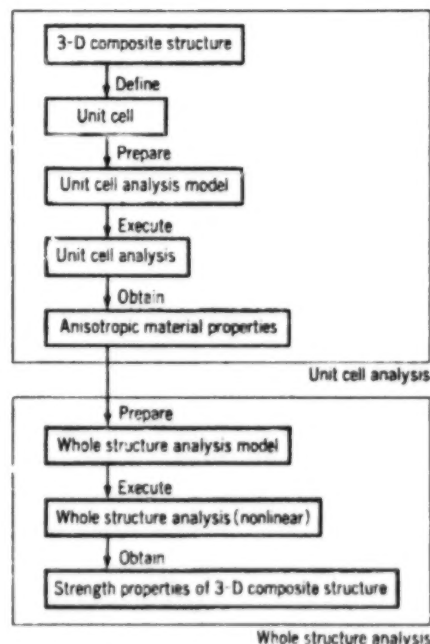
The research reports on the analysis methods for 3-D composites are available in the thesis for the elastic deformation evaluation, all of which are the procedures based on the application of the two-dimensional composite analytic technology. Hence, these procedures could not express the three-dimensional fiber arrangement, one of the principal factors affecting the strength, and it was difficult to develop these procedures to the strength evaluation. Below is the description of the strength analysis technology newly developed for 3-D composite structure. The analysis method has been developed jointly by Kyoto Institute of Technology and Mie University.

#### 3.1 Analysis procedures

Fig. 7 shows the flow of the newly developed analysis procedures. The analysis is composed of the unit cell analysis used for the local part of composite structure and the whole structure analysis. In the case of unit cell analysis, first of all the unit cells are defined from the three-dimensional composite structure for which the analysis is made. The unit cell is a small repeating geometrical unit of fiber architecture, and can be defined in various ways from one structure depending on the difference in weaving pattern according to the structural sections. Next, an analytic model, expressing in detail the fiber architecture for each unit cell is prepared to calculate the anisotropic material properties. In the case of whole structure analysis, the structural analysis model with finite solid elements is prepared, considering the fiber arrangement pattern, and the strength of the whole structure is analyzed. The elements used here are applied with the anisotropic material properties obtained in the unit cell analysis.

#### 3.2 Analytical model

The accuracy of strength analysis largely depends on the accuracy of unit cell analysis. In this research, the fiber



**Figure 7. Flow of Analysis Procedures. The double-stage analysis—unit cell analysis and whole structure analysis—realizes the effective analysis.**

architecture of 3-D composite has been modeled based on a new conception different from the conventional one.

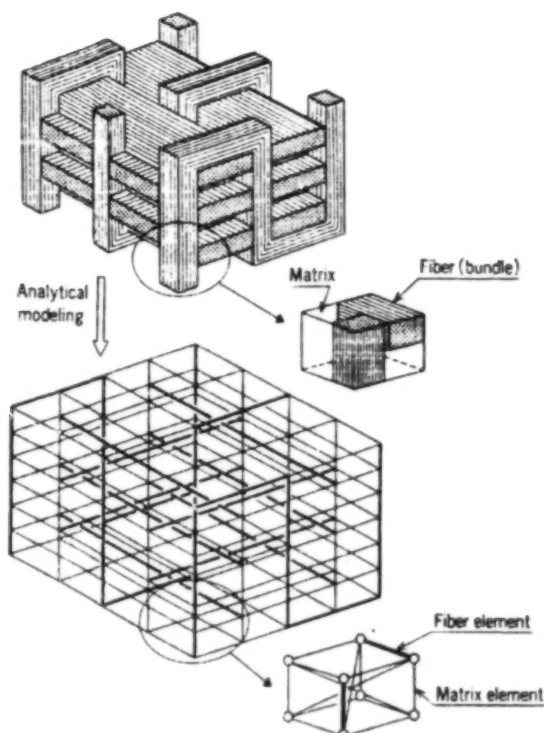
An example of the analytical model for unit cell is shown in Fig. 8. The analytical model was regarded as a rigid frame structure constructed of fiber-beam and matrix beam elements. Since the beam elements are capable of transmitting moment as well as axial force at joints, they can express the continuity of fiber and the linkage between fiber and resin. The fiber elements were faithfully arranged in accordance with the actual fiber weaving so as to express the three-dimensional fiber architecture. Furthermore, since the resin need to deal with complicated load inside the composite such as force between fiber-bundles against the fiber that mainly bears the axial force, the resin elements were arranged from one joint to 14 directions in total to the complicated flow of load.

In the case of strength analysis, the small enforced displacement was given, successively increasing in the loading direction to the analytical model, and the elements that reached the preset failure strength level were removed one after another to calculate the nonlinear behavior up to the failure point against the unit cell part. The mechanical properties of unit cell thus obtained are used as the input data of the solid elements in whole structure analysis. Moreover, only the finite element method was used in the calculation.

#### 3.3 Analytical result

The verification of analysis method was carried out by using OHT (Open Hole Tension) test-specimens (size:



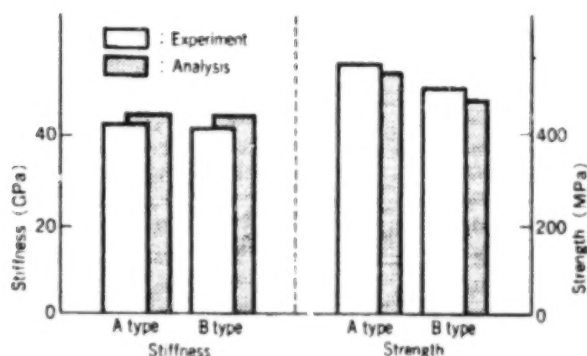


**Figure 8. Analytical Model for Unit Cell Structure.** Analytical model, with the small repeating geometrical unit of 3-D woven structure as the rigid frame structure constructed of beam elements.

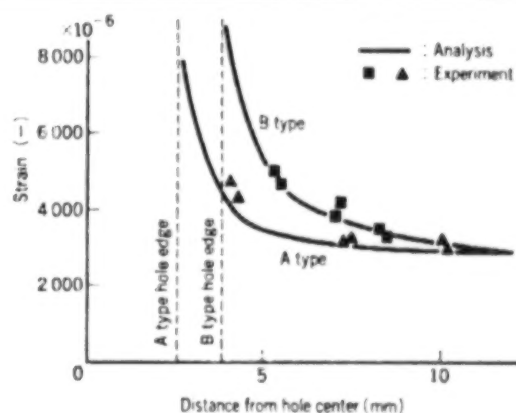
280 x 25 x 4mm), with the fiber arrangement being five-axis and the fiber arrangement ratio in each direction corresponding to the value in Table 1. The carbon fiber was used as reinforcement, and epoxy resin as matrix for the material composition. Two types of test-specimens with different hole diameters (A type: 5mm, B type: 7.5mm) were prepared. Since the fiber arrangement pattern of the test-specimen is uniform, the unit cell in this analysis was also taken as one type and the element division of the whole structure analysis model was carried out taking due account of the stress concentration at the hole edge. The comparison between analytical and experimental results of tensile stiffness and tensile strength is shown in Fig. 9. Both results showed excellent correspondence with each other. Fig. 10 shows the comparison of strain distributions at the neighborhood of open hole in small deformation, indicating excellent correspondence between analytical and experimental results, and verifying high analytical accuracy for the stress concentration at the hole edge.

#### 4. Conclusion

The basic studies were made on the weaving method for 5-axis 3-D fabric and the strength analysis method regarding 3-D composites and the following knowledge was obtained.



**Figure 9. Comparison Between Analytical and Experimental Results.** The analytical and experimental data of tensile strength and stiffness correspond well with each other.



**Figure 10. Strain Distributions at Neighborhood of Open Hole.** Analysis clearly shows the strain distribution owing to stress concentration at the neighborhood of open holes.

- (1) The results of weaving experiment by using the 3-D loom, developed by MHI showed the possibility of continuous weaving of 3-D fabric with 5-axis fiber arrangement, and the newly developed weaving method was found to be applicable to the weaving of large-size 3-D fabric.
- (2) The strength analysis procedure was developed for 3-D composite structure. The procedure features in that an effective and high-accuracy analysis can be made by means of the analytical model through unitization of the local part of the composite and by taking due account of the 3-D fiber architecture, and the effectiveness was verified by using test-specimens with stress concentrated sections.

MHI is planning to aim at developing a new weaving method for 3-D fabric which could be used for primary structural materials from the standpoints of both quality and cost by studying a larger size of woven fabric, higher weaving speed, etc. As for the analysis method, it is planned to improve the accuracy of strength analysis for



large-scale and complicated shape structure and to reduce the calculation cost through computer programming for analysis. Finally the authors would like to express their thanks to Dr. Maekawa and Dr. Hamada of Kyoto Institute of Technology and Dr. Yokoyama of Mie University for their technical support in developing the strength analysis method.

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#### Ceramic Gas Turbines

##### Ceramic Gas Turbine R&D

43070204A Tokyo JAPAN 21ST in English Jul 94 p 44

[Article by Takuki Murayama, Director for Energy Conversion & Utilization, New Sunshine Project Office, Agency of Industrial Science and Technology]

[Text] The conventional gas turbine system has the following desirable features: (1) Its structure is lightweight and compact with a large output per unit weight and installation space; (2) the low vibration facilitates countermeasures for nuisance; (3) relatively low emission of noxious waste gas; (4) the possibility of using many fuel types. The high temperature of waste heat is also advantageous for co-generation purposes.

However, the turbine vanes, which must operate under the highest temperature among all parts, cannot withstand a temperature higher than about 900°C as long as they are made of metal parts. This fact reduces the turbine's thermal efficiency to a low value of 20-30

percent and is the most serious shortcoming of the conventional turbine. The turbine will become an ideal power source towards the 21st century only if its thermal efficiency can be improved. Generally speaking, this can be accomplished by raising the turbine inlet temperature (TIT). But this necessitates the solution of a series of complicated technical problems including the selection of materials and the optimization of structure.

The adoption of ceramic parts is regarded as one of the smartest conceivable options for the solution of these problems at present. Ceramic technology is an extension of the porcelain manufacturing technology for which Japan is especially gifted. Although Japan belongs in the top class of the world in the development of ceramics, further research is indispensable for the development of gas turbine parts in which high thermal resistance, mechanical strength and toughness are simultaneously demanded.

The development of ceramic gas turbines (CGT) is gathering momentum in Europe and America. The United States, in particular, is carrying out several projects such as AGT, ATTAP and recently CSGT, in which some Japanese firms are allegedly playing a vital part by furnishing components.

The development of a 300-kW class CGT is also progressing in Japan, in the framework of the New Sunshine Project sponsored by the Agency of Industrial Science and Technology. Research and development are being pursued in parallel for two models used in co-generation and one model used for portable power generation system.

Basic research on these three types of CGT was concluded by late last year using metallic prototype gas turbines simulating the basic structure of actual models. The results showed that the adoption of ceramic parts exerted no adverse effect on turbine performance but, on the contrary, confirmed the possibility of drastically enhancing the turbine's efficiency. Operation tests are conducted at present with TIT of 1,200°C and using ceramic components in most of the high temperature units.

The R&D are ultimately targeted at the perfection of the waste heat recycling type using heat exchangers and operating at TIT of 1,350°C. It is expected to attain a thermal efficiency of 42 percent and an overall thermal efficiency of 80 percent if combined with the co-generation system. This value is higher than any that has been achieved by a comparable heat engine in practical use at present. Needless to say, CGT will clear the very rigorous environmental standard unattainable by any other heat engine.

The research and development of CGT are thus progressing energetically, widely incorporating the precision processing technology and ceramic manufacturing technology in which Japan enjoys a high degree of proficiency. CGT has become an object of great expectations

as an ideal power source that has boldly confronted the problems of energy and environment.

*Takuki Murayama* was born in 1952. He graduated from the Faculty of Engineering, the University of Tokyo, in 1975, and joined the Ministry of International Trade and Industry (MITI) in the same year. He was appointed Director, Resources Department, Tohoku MITI Office in 1991, and Director, Resources Department, Kanto MITI Office, in 1992. In 1993 he became the Director for Energy Conversion & Utilization in the Agency of Industrial Science and Technology. He is also a vice-chairman for the Committee on Energy Research and Technology of IEA.

#### **Present Development Status of 300kW Ceramic Gas Turbine Technology**

43070204B Tokyo JAPAN 21ST in English Jul 94 pp 45-48

[Article by Hisao Ogiyama, Senior Researcher, Energy Conversion & Storage Department, New Energy and Industrial Technology Development Organization Tokyo, Japan]

[Text]

#### **Introduction**

The gas turbine has a number of merits, such as compact size, light weight, no need for cooling water, compatibility with various kinds of fuel, and easy reduction of environmental impacts such as noise, vibration and exhaust gas, while low thermal efficiency is one of its major demerits. Particularly, the thermal efficiency of the small-sized gas turbine of 500kW or less capacity is as low as 15-20 percent, and such a turbine is currently used only for limited purposes such as an emergency power generation system. The present project is to drastically improve the thermal efficiency of small-sized gas turbine in a nine-year span from fiscal 1988 to fiscal 1996, as a part of the New Sunshine Program of the Agency of Industrial Science and Technology (AIST), Ministry of International Trade and Industry (MITI).

#### **Why Ceramics?**

The most effective way of enhancing the thermal efficiency of the gas turbine is to raise the turbine inlet

temperature (TIT). In the medium- to large-sized turbines, it is possible to raise TIT up to 1,250°C to 1,300°C or higher by cooling the turbine and nozzle blades with compressed air. In the small-sized turbine, however, blades and other components are too small to provide effective cooling structure, and hence, TIT of gas turbine made from metal is limited at 900°C to 950°C. For improving the thermal efficiency of small-sized gas turbines, it is essential to raise TIT without cooling, which requires making components exposed to high temperature, not from metal, but from better heat resistant materials, ceramics.

In the present project, TIT is elevated to achieve higher efficiency by using ceramic components and adopting a regenerative mode.

#### **Objective, Schedule and Organization**

The Project includes R&D for three types of ceramic gas turbine (CGT): two types for cogeneration and one type for mobile power generation plants. To be specific, the development is being pursued under the following schedule and organization, aiming at gas turbines with 300kW of output, thermal efficiency 42 percent or higher, TIT 1,350°C and exhaust gas emission below the level stipulated by law.

#### **Development Steps**

The development of ceramic gas turbines (CGT) with higher TIT will be implemented steadily through the following steps.

1. Basic design: Aiming at a pilot unit, CGT replacing components exposed to high temperature with ceramics are designed.
2. Prototype gas turbine: A metallic gas turbine (TIT: 900°C) of same geometry as CGT is designed, constructed and put to trial operation.
3. Prototype CGT: Based on the results of prototype gas turbine operation, a CGT (TIT: 1,200°C) is designed, constructed and put to trial operation.
4. Pilot CGT: Based on the results of prototype CGT operation, a pilot CGT (TIT: 1,350°C) is designed, constructed and put to trial operation.

1988	1989	1990	1991	1992	1993	1994	1995	1996										
Ceramic Component Fabrication Technology																		
Component Technology (Turbine, Compressor, HEX, etc)																		
Basic Design					Interim Appraisal													
		900°C MGT																
		1200°C CGT																
					1350°C CGT													
Public Acceptability (Environment, Multi-Fuel Capability, Costs, etc)																		
Evaluation of Ceramic Component & Engine System																		

Table 1. R&D Schedule of 300 kW CGT Program

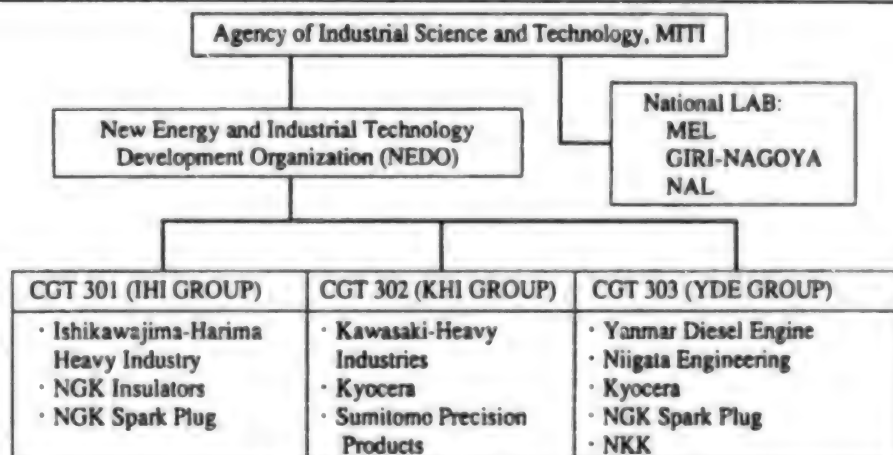


Table 2. Organization of 300kW CGT R&D Program

Nick Name	301	302	303
Engine Type	Single-Shaft Regenerative	Two-Shaft Regenerative	
Compressor	Axial / Centrifugal	Centrifugal	
Turbine	Two Stage Axial	CGT : Axial PT : Axial	CGT : Radial PT : Axial
	Ceramic Blade / Metal Disc	CGT : Ceramics PT : Ceramic Blade/Metal Disc	
Heat Exchanger	Shell & Tube (Ceramics/Metal)	Plate Fin Type (Metal)	Rotary Regenerator (Ceramic Core)
Application	CO-Generation		Mobile Power Plant

Table 3. Feature of 300kW CGTs

### Operation Research

Preceding or in parallel with the development of the CGT main component described above, R&D of heat resistant ceramic components and elementary technology will be pursued while keeping organic coordination and close collaboration between individual tasks.

### Technological Development Tasks

The development of CGT involves two tasks: enhancing performance and applying ceramics.

#### I. Tasks to Enhance Performance

- 1) Select optimum pressure ratio.
- 2) Improve hydrodynamic efficiency and reduce leakage loss for each component.
- 3) Implement small-sized regenerator of high efficiency and low pressure loss.
- 4) Establish combustion technology for reduced NO<sub>x</sub> emission.

#### II. Tasks for Ceramic Components

##### 1) Tasks for Ceramics Application

It is necessary to monitor temperature and stress of ceramic components by using FEM and to take the following facts into consideration.

1. Seek shape and structure to exclude a concentration of stress and impact.
2. Reduce tensile stress as far as possible.
3. Minimize surface defect and residual strain at the time of fabrication.
4. Absorb the difference in thermal expansion between ceramics and metal.

##### 2) Tasks for Manufacturing Ceramic Components

1. Develop materials of high temperature strength, high oxidation resistance and high heat impact resistance, suited for application sites.
2. Fabricate components so as to fully exhibit the material merits.
3. Establish fabrication technology of high accuracy and low cost.
4. Establish technology to join and butt ceramics with metal.

##### 3) Technology for evaluating reliability

In order to establish technology for assessing reliability, technologies for evaluating mechanical strength and service life and for non-destructive testing are studied.

### Present Status of Development

#### (1) R&D of Heat-Resistant Ceramic Components

In regard to components of the prototype CGT (TIT: 1,200°C), the manufacturing conditions, evaluation and warranty of strength and other characteristics have been studied. For components of complicated geometry, such as the turbine blade, the trial manufacture of simple-shaped model preceded the study of manufacturing conditions for blades of actual geometry. Large-sized components such as scroll, combustor, etc. are manufactured in divided mode, and, for instance, divided parts of CGT 302 are assembled by binding and joining with ceramic fiber.

While some components require continued efforts to improve the geometrical accuracy, most of the accuracy and strength requirements in design are fully satisfied. In each group, the selection of improved ceramic materials to be used in the pilot CGT, which is the final goal of the Project, has been finished, and R&D on fabrication technology for ceramic components has been initiated on the basis of these findings.

#### (2) Studies on Elementary Technologies

In order to improve performance and reliability of individual components, such as turbine, compressor, combustor, heat exchanger, and so on, means of evaluation and improvement are being studied by using component testing systems.

##### 1. Turbine

In parallel with studies on performance enhancement, efforts are being made to investigate countermeasures for FOD, geometry to reduce stress, and buffering materials for obtaining uniform distribution of stress in the hybrid type rotor with ceramic blade combined with metal disc.

##### 2. Compressor

Studies on improvement of efficiency/pressure ratio and securing surge margin on the part of the compressor are conducted integratively, for the purpose of contributing extensively to the performance of the gas turbine.

##### 3. Combustor

In order to implement combustion with limited NO<sub>x</sub> emission, it has been decided to adopt the pre-mixed lean burn system, and the combustor geometry and control method are being studied.

##### 4. Heat Exchanger

R&D efforts are centered on increasing the size of the ceramic multiple tube heat exchanger for CGT 301, on the application of super alloy to plate-fin heat exchangers for CGT 302, and on the improvement of sealing characteristics of the rotary regenerator for CGT 303.

##### 5. Thermal Impact Test

A thermal impact test was carried out with individual components and their assemblies to confirm integrity.

### (3) Design and Trial Operation

A prototype gas turbine (metal, TIT 900°C) of same geometry as CGT has been designed, manufactured and operated, and the prototype CGT (TIT 1,200°C) was designed and manufactured on the basis of these studies. Figs. 1 to 3 show outer views of the three types of CGT.

Currently, three types of CGT are being put to trial operation. In the trial operation, components are replaced with ceramic ones step by step, while checking the rotation stability and component integrity at various combinations of parameters such as rotational speed, TIT and tip clearance. Though experience from the trial operation is not yet adequate, three of CGT have been successfully operated at TIT 1,200°C for a short time and a bright prospect is suggested for the final goal of TIT 1,350°C.

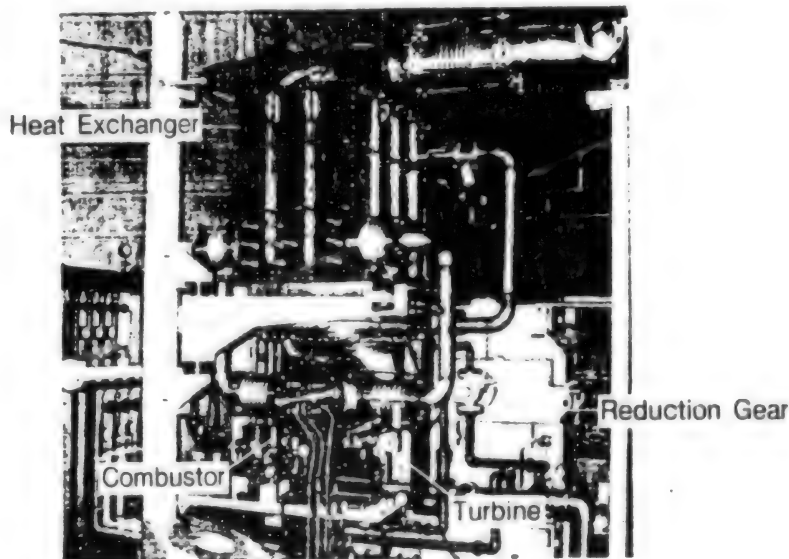


Figure 1. External View of CGT 301

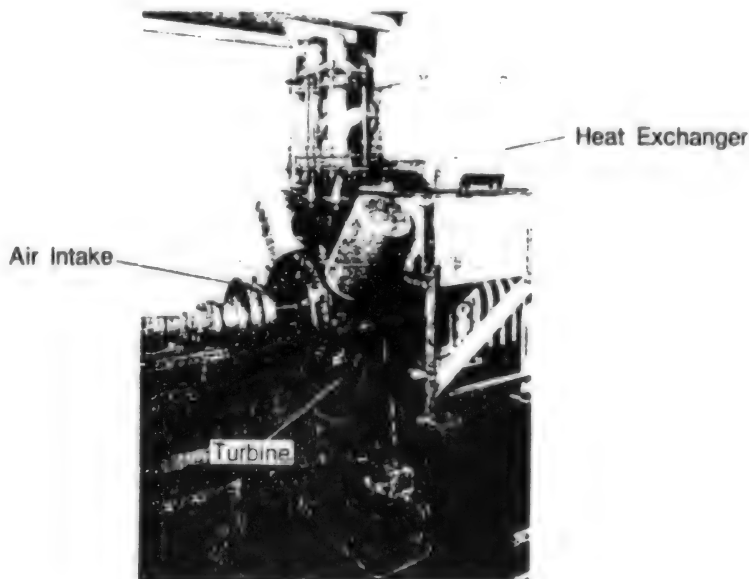


Figure 2. External View of CGT 302

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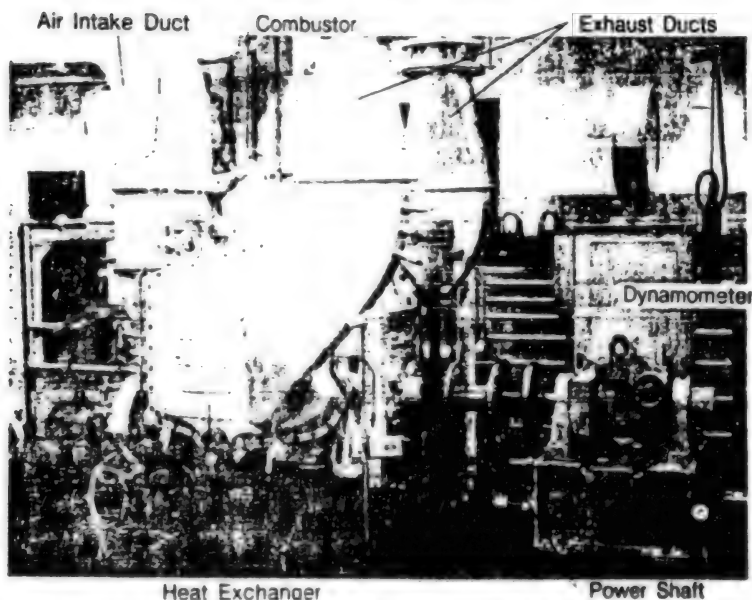
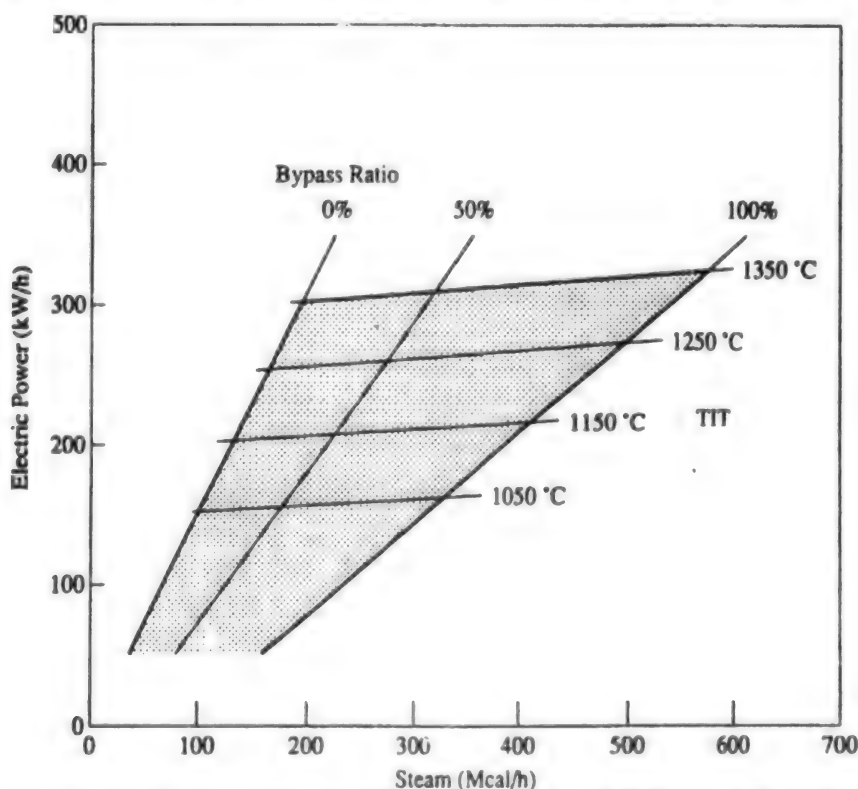


Figure 3. External View of CGT 303

### Expectation for Practical Application

Among various areas to which CGT may be applied, the characteristics of the cogeneration system (CGS) based on CGT will be described. In this system, the ratio of electrical to thermal output can be controlled readily and widely, by regulating the exhaust gas flow bypassing the CGT regenerator. Fig. 4 shows the control range of thermal/electrical

output ratio in the CGT 302. For instance, at electrical output of 300kW, the steam output (8 kg/cm<sup>2</sup>G) can be adjusted over a range from 200 to 590 Mcal (400 to 1,200 kg/h). The CGS is a very effective and easy-to-use system for an area where the seasonal variation of energy demands is wide, like Japan, and it is no exaggeration to claim that CGS can be realized only with CGT.



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### Conclusion

While ceramics have been used as heat-resistant structural materials, they have not yet been used for gas turbines where high accuracy and operation under very severe conditions are required. The contracted enterprises in this project have been challenged to perform this difficult task as pioneers. In the operation studies of the prototype CGT (TIT 1,200°C), it is expected that efforts of Project participants will bear fine fruits and valuable data will be collected toward the development of the pilot CGT (TIT 1,350°C), the final goal of the Project. I hope the results of the present Project lays the foundation for the popularization of structural ceramics.

*Hisao Ogiyama* was born in April 1944. He graduated from the Department of Chemical Engineering, Faculty of Polytechnic, Tokyo Institute of Technology, in 1969.

Ogiyama joined the New Energy and Industrial Technology Development Organization (NEDO) in 1986 and was engaged in development of phosphoric acid fuel cells. Since 1991, he has been devoting himself to the CGT project. Ogiyama is now a senior researcher of the Energy Conversion and Storage Department at NEDO.

### Development of the 300kW Class Gas Turbine

43070204C Tokyo JAPAN 21ST in English Jul 94 pp 50-51

[Article by Kazuho Akiyama, Deputy Manager, Ceramic Gas Turbine Project Research Institute, Ishikawajima-Harima Heavy Industry Co., Ltd.]

[Text]

### Characteristic Aspects of CGT301

The 300-kW-class ceramic gas turbine CGT301 has been in development since 1988 by Ishikawajima-Harima Heavy Industries Co., Ltd. in collaboration with NGK Insulators, Ltd. and NGK Spark Plug Co., Ltd. under contract with the Agency of Industrial Science and Technology of the Ministry of International Trade and Industry with the administration by the New Energy and Industrial Technology Development Organization.

CGT301 is a recuperated, single-shaft ceramic gas turbine for co-generation applications. The primary part of CGT301 is schematically shown in Fig. 1. In consideration of the applicability of the basic design concept, not only to the 300-kW-class but also to larger size machineries, the hot section of the system is designed according to the axi-symmetric design concept, which is advantageous to reduce the size and unexpected deformation of the ceramic parts. Figure 2 shows the ceramic parts of CGT301 together with the cross sectional drawing of its hot section. The turbine is a two-stage axial flow type. As the primary feature of the turbine, the rotors are composed of ceramic blades inserted into metallic disks (Photo 1) according to the design concept mentioned above, though this type of turbine rotor has not yet been successfully developed anywhere in the world. Ceramic parts are also applied to the high temperature static portion of the turbine, such as the nozzle-vanes and the gas-path parts. The combustor is located co-axially to the turbine shaft also due to the same design concept. The compressor is a combination of axial flow and radial flow types. The heat exchanger is a shell-and-tube type, the higher temperature portion of which is composed of ceramic parts.

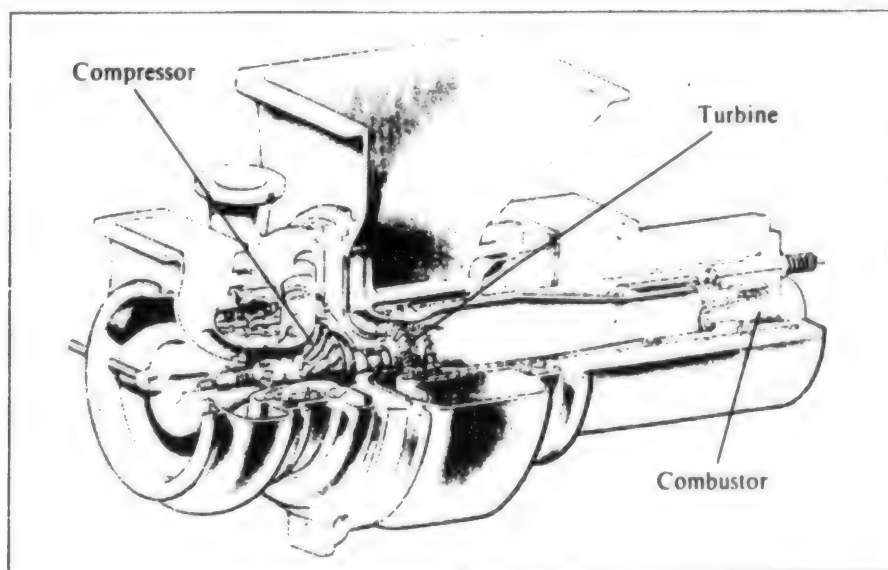


Figure 1. Ceramic Gas Turbine CGT301

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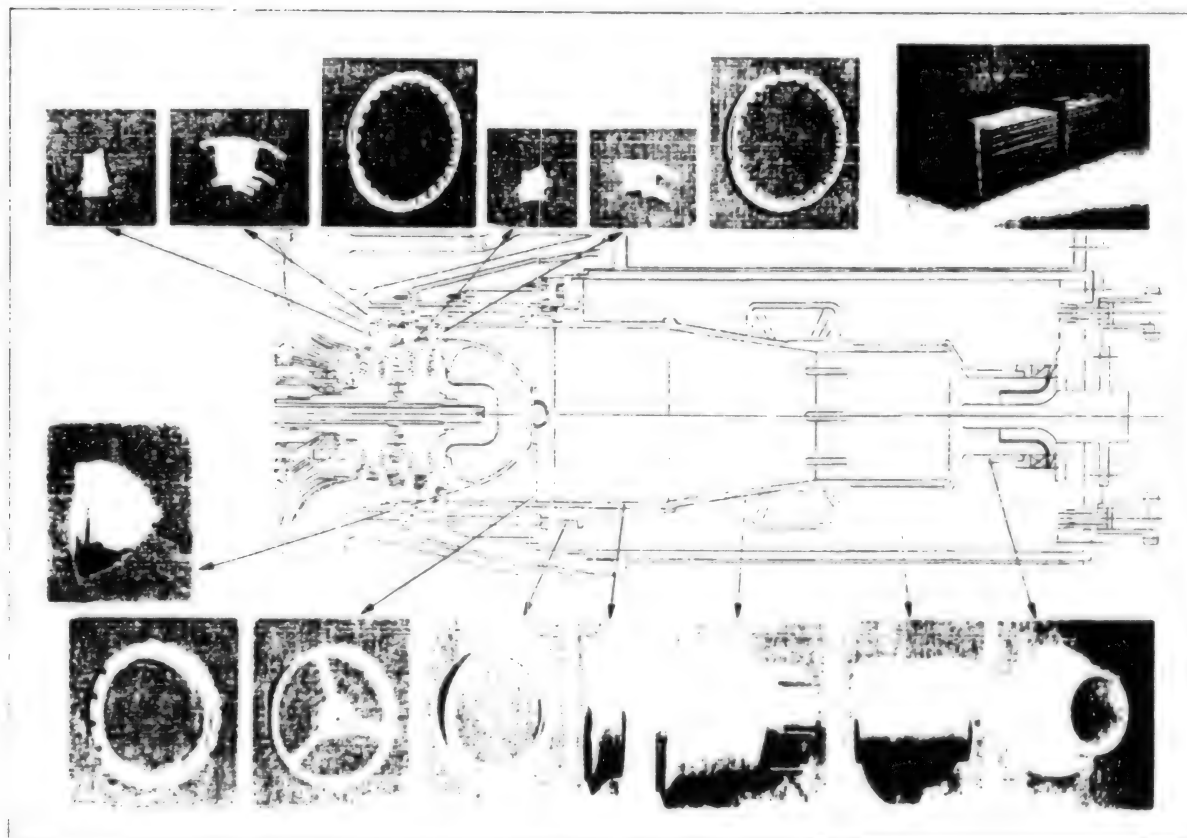


Figure 2. Ceramic Parts in CGT301



Photo 1. Ceramic Blades with Metallic Disk

The specified development targets of the primary type ceramic gas turbine of CGT301 are shown in Table 1.

**Table 1. Targets in the Development of Primary Type Ceramic Gas Turbine of CGT301**

Item	Target
Turbine inlet temperature	1200°C
Turbine speed	56,000RPM
Compressor efficiency	79%
Combustion efficiency	99%
NO <sub>x</sub> emission	70ppm
Turbine efficiency	83%
Heat exchanger efficiency	84%

#### Development of Component Technologies

Development of fabrication technologies of high temperature parts with refractory and high-strength ceramics has been carried out, and ceramic parts with high-quality and precise geometry have been successfully fabricated.

Ceramic parts to be installed in the engine system have been tested in the following manner to prove their reliability. Ceramic blades have been successfully tested

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by hot-spin testing at the gas temperature of 1100°C up to 110 percent of the standard rotational speed. Ceramic static parts such as nozzle-vanes, gas-path parts, combustor liners have been installed in a test rig basically with the same configuration as the engine, and have also been successfully tested by the thermal fatigue of 100 cycles between 1200°C and 300°C.

Development of engine component technologies, i.e., compressor, combustor, turbine and heat exchanger, has been carried out to attain the required structural reliability and efficiency of the components. The target values of the efficiency of the components shown in Table 1, were basically attained in the component rig-tests.

#### Development of Primary-Type Ceramic Gas Turbine CGT301

Ceramic components have been installed in the CGT301 engine (Photo 2) step by step. Eventually, first-stage turbine blades, turbine nozzle-vanes, gas-path parts and combustor liners as ceramic parts have been installed in the engine, and a turbine inlet temperature of 1200°C has been attained at the standard rotational speed of 56,000RPM.

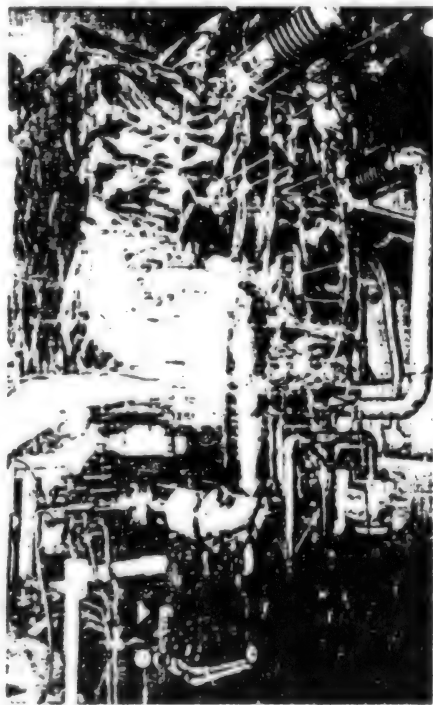


Photo 2. CGT301 Engine Assembly

Further research and development efforts will be continued to establish the structural reliability of the engine for prolonged and/or non-steady state operations, as well as to attain higher turbine inlet temperature (final target 1350°C) and higher efficiency of the engine in the research program.

Kazuho Akiyama was born on July 1, 1944. After graduating from the Department of Mechanical Engineering, Keio University, he earned a Degree of Master of Mechanical Engineering in 1970, Keio University. He entered Research Institute Ishikawajima-Harima Heavy Industry Co., Ltd. in 1970. He has been engaged in the research and development of turbomachineries, and since 1987 he has been working on the ceramic gas turbine R&D project.

#### Kawasaki Heavy Industry's Ceramic Gas Turbine Development

43070204D Tokyo JAPAN 21ST in English Jul 94 pp 52-53

[Article by Tetsuo Tatsumi, Manager, Development Section, Engineering Department]

[Text]

##### 1. Preface

The Industrial Gas Turbine Division of Kawasaki Heavy Industries (KHI) has been developing and providing gas turbines, that have output power from 25kW to 6MW for electric power generation. When "Ceramic Gas Turbine Development Project" was started by the New Energy and Industrial Technology Development Organization (NEDO) in 1988, KHI was entrusted with 300kW ceramic gas turbine development for co-generation use.

The development objective is to achieve 42 percent thermal efficiency at 1350°C TIT by developing the recuperated 2-shaft ceramic gas turbine "CGT302".

This development is progressing according to the following four steps, and we are now going to Step 4 from Step 3.

Step 1: Basic design

Step 2: Basic MGT (Metal base engine)

Step 3: Basic CGT (1200°C ceramic gas turbine)

Step 4: Pilot CGT (1350°C ceramic gas turbine)

Step 2 and 3 correspond to the part load condition of Step 4.

##### 2. Design feature of CGT302

###### 2.1 General construction

All ceramic components for the engine test of Basic CGT are shown in Fig. 1. The ceramic material is applied to the high temperature components, such as the combustor liner, the scroll, turbine nozzles, blades and other hot gas passage components. The material of all the ceramic components is silicon nitride.

###### 2.2 Ceramic material application technology

Ceramic materials have many advantages for the application of high temperature gas turbines, but there are

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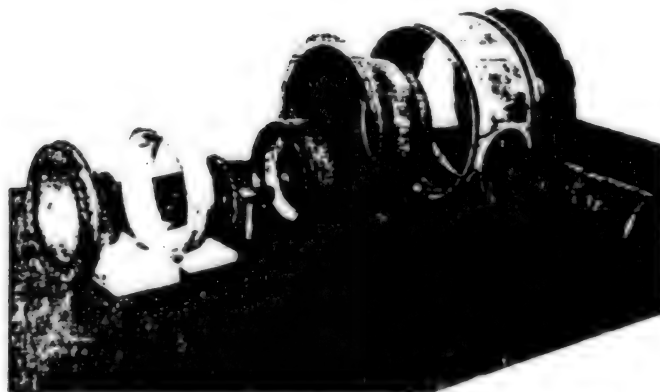


Figure 1. Ceramic Components for Basic CGT

still several problems for practical use such as brittleness and low coefficient of thermal expansion. It is necessary to take into account these characteristics for the successful application of ceramic components. Therefore, we developed the original design methodologies as follows.

#### 2.2.1 The composite-component structure

The large and/or complicated shaped components such as the Gas Generator Turbine (GGT) Nozzle, the Power Turbine (PT) Nozzle and the turbine scroll have large temperature distribution that will cause serious thermal stress. We adopted the composite-component, namely a monolithic-FRC hybrid structure, to reduce thermal stress. For example, the GGT and PT nozzle are separated into each vane segments and a cylindrical support, and then assembled as a composite-component structure. Fig. 2 shows the PT nozzle assembly.

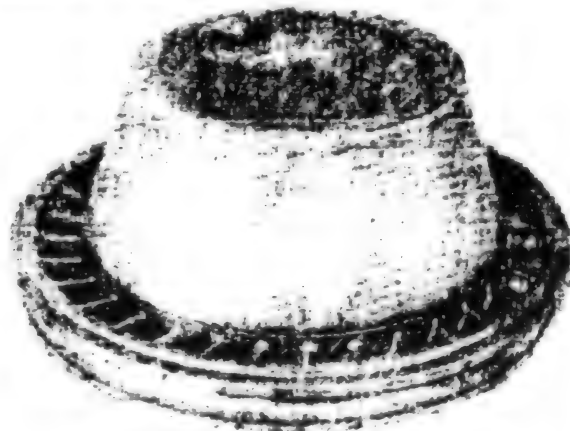


Figure 2. PT Nozzle Assembly

#### 2.2.2 Independent and stress free supporting structure

There is a large difference in the coefficients of thermal expansion between ceramics and metals. It will cause

defects in the ceramic components due to the interference of structure unless we take measures against this problem. We adopted the independent and stress-free supporting structure to avoid this problem using ceramic coil spring or wave ring that absorbs the deviation of thermal expansion between ceramics and metals.

#### 2.2.3 Heat exchanger

It is effective to equip the gas turbine with a heat exchanger to improve the gas turbine efficiency. We adopted rather low efficiency for the heat exchanger, to reduce its size and dimensions. Consequently, the optimum pressure ratio, which maximizes gas turbine efficiency, resulted in a higher value than that of automobile gas turbines with rotating regenerators. We chose a metal heat exchanger instead of a ceramic one, because the higher pressure ratio enabled lowering the inlet temperature of a heat exchanger.

### 3. Test Results of CGT302

We have already successfully completed Steps 1, 2, 3 and are now going to proceed to Step 4.

#### 3.1 Engine Test of the Basic MGT (Step 2)

The MGT is the test bed for the CGT. In the MGT, all ceramic components of the CGT are replaced by metal parts which have the same aerodynamic geometry as the CGT. We confirmed the stable operating conditions, such as rotation stability, vibration, etc., and performance to utilize the data for the next step. We achieved the expected performance for the MGT, i.e., 23 percent thermal efficiency and 59kW output power at 900°C turbine inlet temperature.

#### 3.2 Thermal Shock Test of Stationary Components for the Basic CGT (Step 3)

Before the engine test, we evaluated the thermal shock durability of stationary ceramic components, such as the scroll and the nozzles, simulating the engine condition. The

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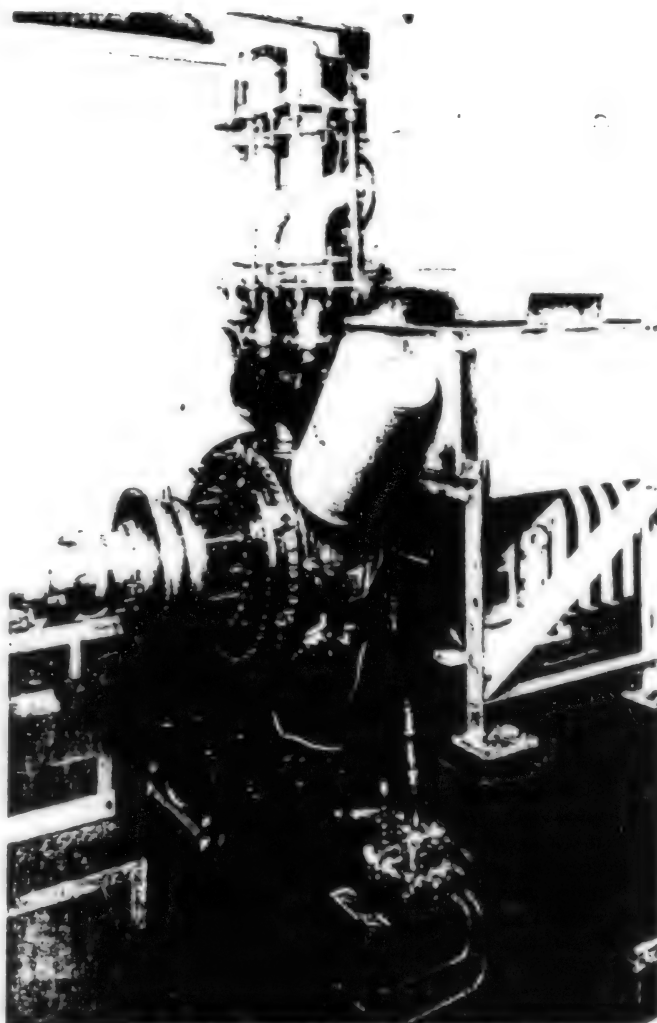


Figure 3. External View of the Basic CGT

100 thermal cycles of endurance test, in which gas temperature changed instantaneously between 150°C and 1200°C, was carried out, and no ceramic components were damaged.

### 3.3 Engine Test of the Basic CGT (Step 3)

After the stepwise evaluation of ceramic components in the engine, we proceeded to full ceramic engine tests. After several trials, we have achieved the rated condition operation of the Basic CGT. We have gotten the following data.

TIT: 1230°C

Output power: 130kW

Thermal efficiency: 28.8%

Figure 3 shows the external view of the Basic CGT.

These descriptions are the results of the Ceramic Gas Turbine Development Project promoted by NEDO.

*Tetsuo Tatsumi* was born in 1949. He graduated from the department of Mechanical Engineering, Osaka University in 1971 and joined Kawasaki Heavy Industries in the same year. He has been engaged in the development of industrial gas turbines. Tatsumi is now manager, Development Section, Engineering Department, Industrial Gas Turbine Division.

### Development of a Two-Shaft Regenerative 300kW Class Gas Turbine

43070204E Tokyo JAPAN 21ST in English Jul 94 pp 54-55

[Article by Sadao Arakawa, Leader, CGT Project Team, Yanmar Diesel Engine Co., Ltd.]

[Text]

#### 1. Introduction

The gas turbine is characterized by a small compact size, little vibration and easy reduction of noise. Furthermore, the conversion from liquid fuel to gas fuel is

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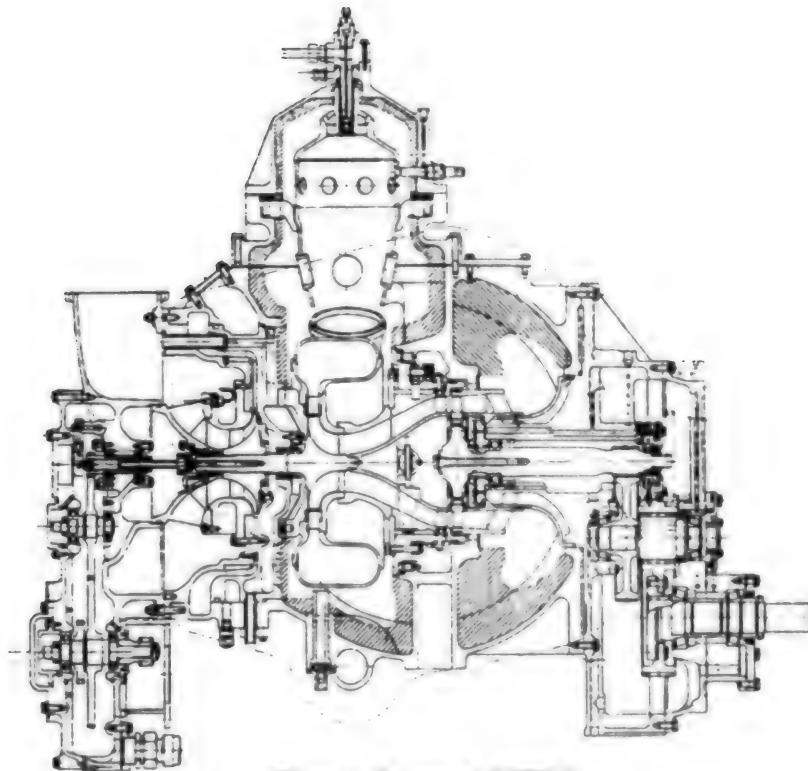


Figure 1. Scheme of CGT303

possible without a major structural change. Another advantage is the clean exhaust gas. Low thermal efficiency is the only drawback. If this problem is solved, the gas turbine will surely play a vital part as a source of motive power in the 21st century.

The "Research and Development of the Ceramic Gas Turbines (CGT)," which was started in 1988 as a part of the state's Sunshine Project, is a new quest for this possibility. New structural ceramics, which have achieved remarkable technological progress in recent years, are employed for the high-temperature components of the gas turbine, while waste heat is recovered with heat exchangers. These innovations are aimed at achieving a thermal efficiency of 42 percent. Energy saving is sought while the emission of  $\text{NO}_x$  and  $\text{CO}_2$  is reduced.

Yanmar Diesel successfully developed a small gas turbine used for an emergency power source in 1984. In addition, we industrialized a 2-shaft gas turbine for driving industrial machines, commercialized in 1992, and the combined sales of both types have now reached about 700 units. Based on the experience gained through this R&D, Yanmar joined the development group of Niigata Engineering Co., Ltd., Kyocera Corp., NGK Spark Plug Co., Ltd. and NKK Corp. and has been engaged in the development of the 300-kW class ceramic gas turbine (CGT 303) for the use of the portable generator set as a project commissioned by NEDO (New Energy and Industrial Technology Development Organization).

## 2. Features of CGT 303

CGT 303 adopts the 2-shaft system and variable power turbine nozzle in order to raise thermal efficiency under partial load. The gas generator turbine is of the radial type, and the power turbine is of the single axial flow (hybrid) type. Two rotary heat exchangers are provided on both sides of the engine to achieve the latter's compactness. The pressure ratio is set at a low value of 4.5 in view of the expected high temperature. This feature is required to adopt effectiveness of heat exchanges of larger components for CGT 303, including the gas generator turbine with a diameter of 163mm. However, the stress value at the design point (5,500rpm and 1,350°C) is kept below 30kgf/mm<sup>2</sup>.

## 3. Current Status

The member companies of the group energetically carried out research on the elementary technologies of the compressor, the combustor, the heat exchanger, etc., as well as research on geometry, strength evaluation and improvement of ceramic components. Hot spin tests of the turbine and thermal shock tests of stationary components were conducted to test the strength of components made on trial. The thermal shock test was conducted by building ceramic components in the engine housing just like an actual engine. The cumulative test frequency in the gas temperature range of 600-1,200°C reached about 600 cycles.

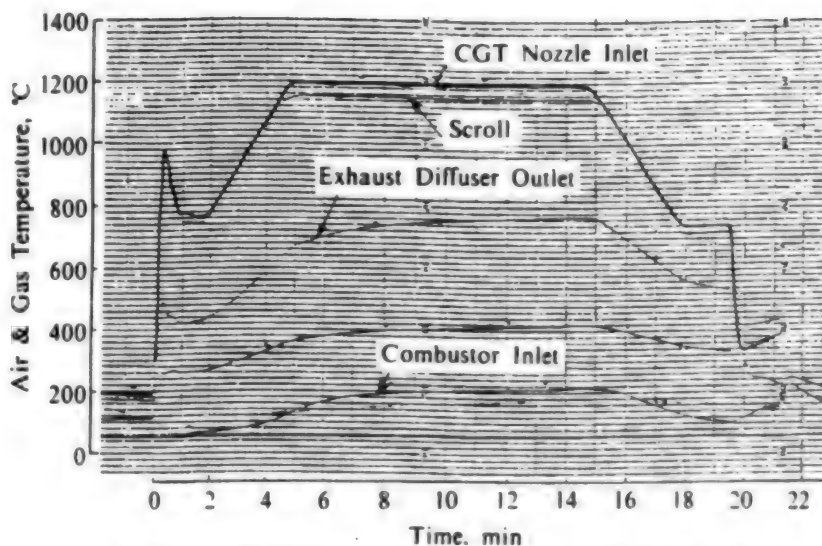


Figure 2. Temperature Schedule in 1200°C Thermal Shock Test

A series of tests indicated the possibility that the components can withstand the actual operation. Hence, we gradually converted into ceramics the stationary components such as the combustor and the scroll as well as the gas generator turbine and started the test operation of the so-called ceramic gas turbine. Operation up to TIT 1,200°C and 150kW was successfully carried out without mounting rotary heat exchangers, although the duration was short.

In parallel, we are conducting the development of the rotary heat exchanger which is indispensable for higher thermal efficiency. Already a temperature effectiveness of over 90 percent has been achieved. The present research is directed at reducing the air leak which still remains considerable.

#### 4. Conclusion

- 1) The development of CGT 303 up to now has confirmed that the strength of ceramics can be enhanced to a level applicable to an actual engine.
- 2) The successful operation up to TIT 1,200°C has indicated the possibility of a non-cooled small gas turbine. Based on this experience, we are now working on operation tests up to 1,350°C.
- 3) Development of the technology to reduce air leakage is urgently awaited for the rotary heat exchanger.

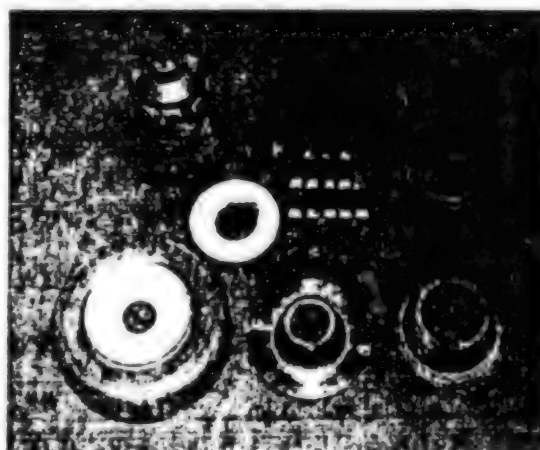


Figure 3. Ceramic Components Thermal Shock Test (1200°C)

Sadao Arakawa was born in Hiroshima Prefecture in 1941. He graduated from Gifu University and joined Yanmar Diesel Engine Co., Ltd. in 1965. Since then he has been engaged in the research and development of diesel engines, gas engines and gas turbines. He is at present Leader of the CGT Project.

**Space Agency Proposes Reusable Shuttle Orbiting Fuel Station as Way to Cut Costs**

43070208A Tokyo THE NIKKEI WEEKLY in English  
18 Jul 94 p 14

[Text] By switching from single-use rockets to re-usable launch vehicles and by placing maintenance and fuel stations in orbit, the National Space Development Agency of Japan (NASDA) believes it can reduce the operating costs of its space program by as much as 90 percent.

This scenario is spelled out in a NASDA study on the repercussions of space infrastructure which includes Japan's first detailed cost analysis of a re-usable space system.

The study proposes the introduction of a revolutionary space infrastructure that would bring space transportation costs down in line with airplane transportation costs.

Space transportation costs now devour as much as 25 percent of the \$70 billion spent on space programs worldwide. If such costs could be reduced to just one-tenth of the current amount, then such programs as the exploitation of moon resources could be carried out without the need to secure larger budgets, the report concludes.

The report proposes a new space infrastructure, which would include: a launch vehicle similar to the space shuttle capable of traveling back and forth between earth and space; an orbiting operations center which could perform maintenance work on satellites; a number of orbiting fuel stations and inter-orbit transport vehicles. All systems would be designed so that they could be used again.

The key to success is the development of a re-usable launch vehicle to replace the single-use rockets now

employed. Sometime this fiscal year, the Science and Technology Agency's National Aerospace Laboratory will begin research and development of a re-usable rocket engine. The concept now being considered is a single-stage rocket along the lines of the Delta Clipper being developed by the U.S.

In a cost analysis of the new space infrastructure, the report calculates \$25 billion for the development and introduction of one shuttle-like launch vehicle, \$12.6 billion for seven fuel stations, and \$8.7 billion for six inter-orbit transport vehicles.

These systems would be developed over a 10-year period starting in 1995. The infrastructure would be launched into space in 2005, and the entire system could be operated for 20-30 years.

**Cost effective**

The initial investment for this reusable delivery system, which includes development costs, would be significantly more expensive than the current single-use systems. However, costs would equal out by the year 2020, and after that the re-usable system would become more cost-effective, the report argues.

Annual operating costs of the reusable system would be about \$2 billion, or roughly 25 percent of the \$7.5 billion now spent annually on the current system. NASDA believes that with the introduction of further improvements, costs could eventually be brought down to just 10 percent of existing levels.

The proposed space infrastructure would also considerably extend the lifespan of satellites, since crews could replace used batteries and refuel them. Moreover, since repairs could be performed in space, it would no longer be necessary to build the satellites to such exacting standards. Hence, development and construction costs would be significantly reduced as well.

### MHW To Aid Pharmaceutical Companies Research Activities

94FE0691A Tokyo NIHON KEIZAI SHIMBUN  
in Japanese 25 Mar 94 p 7

[Text] The Ministry of Health and Welfare plans to help pharmaceutical companies strengthen their research and development. Their plan is to open a new division in July, which will be in charge of issues concerning new drug development; sharply increase their financial support for research and development of drugs against rare and malignant diseases; develop a cooperative relationship among the industry, academia, and government; and become actively involved in the improvement of the environment for the research and development.

The Office for the Promotion of Advanced Pharmaceutical Technology (currently a section of the Division of Economic Affairs in the Pharmaceutical and Supply Bureau) will be promoted to become the new division called the Division for the Advancement of Research and Development. Along with this promotion, the number of personnel will be increased from 5 to around 14.

After such strengthening of the support system, they will increase the financial support for research and development of drugs (orphan drugs) which are used against the malignant diseases that affect only a small number of people. The amount of funds for the orphan drug development budgeted for the fiscal year of 1994 is about ¥400 million which is twice as much as the budget for the previous year. It is expected that this will be used for funding more than 30 drugs. The research and development of drugs for AIDS treatment will also be supported.

As for the cooperation among industry, academia, and government, some proposals are currently being considered. An example would be to assemble a number of academic researchers and pharmaceutical companies and start a research committee supervised by the Ministry of Health and Welfare. Another plan under consideration is to collaborate with pharmaceutical companies to establish a self-supporting system within the country to obtain a sufficient supply of medicinal plants.

The Ministry of Health and Welfare says, "Although the research and development fund is currently increasing, it may start to decrease in the future. We would like the pharmaceutical companies to take the present opportunity to consolidate the foundation of their research and development."

### Japan Tobacco Inc. Develops High Transgenic Efficiency for Rice

94FE0691B Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 1 Apr 94 p 17

[Text] The Japan Tobacco Inc. (JT) has developed a transgenic technique using the soil microbes called agrobacteria which can provide high efficiency in transferring target genes into rice plants. In an experiment with

the Koshihikari rice, the new technique achieved transgenic efficiency which is approximately 20 times as high as that of the conventional method. The new technique may be used not only for rice but for other kinds of grain such as wheat and corn. The company hopes that the new technique will accelerate the development of new rice breeds, etc. It will be presented at the meeting of the Japan Society of Breeding which opens on April 2.

The transgenic technology is used to transform rice plants in order to develop resistance to the stripe leaf blight or to improve the taste of rice. Unfortunately, there has been a problem of low efficiency in transferring target genes.

The new technique uses the soil microbes called agrobacteria as the vector (gene carrier). In this method, a plasmid (chromosome) in an agrobacterium is recombined with certain target genes. A rice plant cell is infected with this agrobacterium so that the target genes are brought into the cell. This has been a difficult method to be used for rice plants. However, by bisecting two plasmids with a section for making the agrobacterium infectious and a section where the target genes are recombined, the agrobacterium is made highly infectious to the rice plant cell. The company has named this method a "super-binary vector."

In an experiment, a gene resistant to an antibiotic called hygromycin and a gene from an enzyme which develops a blue color were introduced into Koshihikari rice plants. The proportion of the regenerated plants which manifested the target genes was 18.8 percent. It is only 1 percent with the conventional methods such as the electroporation method (to electrically stimulate a protoplast with its cell membrane removed) and the use of a binary vector. Therefore, the transgenic rate with the new method is nearly 20 times higher.

This method can shorten the amount of time between the transgenic process and the plant's regeneration. It does not require cell membrane removal for making a protoplast. In addition, the incidence of mutation can be greatly reduced. The company thinks that the new technique may be used not only for rice but for other kinds of grain such as wheat and corn.

### Japanese Venture Capital Companies Invest \$3 Million in U.S. Bio-Venture Company

94FE0786D Tokyo NIHON KEIZAI SHIMBUN  
in Japanese 20 Jun 94 p 15

[Text] In cooperation with Nichimen Corporation, four powerful venture capital (VC) companies including Techno-Venture Co., Ltd. (Chiyoda-ku, Tokyo; Masao Kamijo, president) have invested \$3 million in the American bio-venture company, GenPharm International (based in California). Bio-venture companies require large amounts of development funds, and it has become increasingly difficult to raise sufficient capital even in the U.S. where many dedicated VC companies



are located. We can expect to see more cases in the future in which Japanese commercial houses proficient in raising capital and Japanese VC companies join forces to invest in American bio-venture companies.

GenPharm was established in 1988 as a subsidiary of the well-known American bio-venture growth company Genentech (Robert Swanson, chairman). The company is involved in cutting-edge research on the production of proteins used in anti-cancer drugs and health foods by recombinant animals such as cows.

The VC companies involved are Techno-Venture, Kokusai Finance Company, Ltd. (Chuo-ku, Tokyo), Daiwa Business Investment Co., Ltd. (Chuo-ku, Tokyo), and Fujigin Capital Company (Shinjuku-ku, Tokyo). Techno-Venture, which supported the original founding of Genentech, acted as the liaison and procured the investments. This is Nichimen's first investment in a venture company, and it expects to profit by selling its stock in venture company in the future. A spokesman from Nichimen's Foreign Exchange and Securities Division says, "Our policy is to look aggressively for outstanding companies to invest in."

GenPharm has already received a total of \$31 million from powerful VC companies in Europe and the U.S. It is also slated to receive financing from the governments of the U.S. and Holland, and other support in the form of subsidies and grants. Because the development of new drugs requires considerable amounts of money and time for research, GenPharm decided to procure capital from Japan and other countries.

The company has cooperative alliances to develop new drugs with the large U.S. pharmaceutical makers, Collagen Corporation and Bristol-Myers Squibb, and the Japanese pharmaceutical maker Eisai Company, Ltd.

#### **Kumagai Gumi Co., Ministry of Construction Develop High-Performance Wastewater Treatment System Using Microorganisms**

94FE0786E Tokyo KENSETSU TSUSHIN SHIMBUN  
in Japanese 24 Jun 94 p 12

[Text] In joint research the Kumagai Gumi Company and the Ministry of Construction's Building Research Institute have developed a mid-sized, high-performance wastewater treatment tank, and they have compiled the results of the tank's treatment performance after about one year of actual use. Results of 24-hour studies performed during the summer (September) and winter (November) and changes over time for one-month periods were announced for performance of the system on SS (suspended solids) and BOD (biochemical oxygen demand). The system achieved its water quality targets by taking influent with both SS and BOD levels of about 120 mg/L and reducing the SS concentration to a constant 20 mg/L or less (with an average of 10.0 mg/L) and the BOD concentrations to a constant 10 mg/L or less (with an average of 7.1 mg/L). The system is designed to

handle the wastewater of 200 people or more, and with this kind of effectiveness, it can be used for combined wastewater treatment systems for 1000 people or less. Based on this data, the company will seek a general evaluation in addition to the specific evaluation it has requested from the Japan Building Center. The company plans to develop this system for golf courses, resorts, multiple-unit dwellings, office buildings, and areas without established wastewater treatment facilities.

In the activated sludge process that is used in conventional wastewater treatment systems, the wastewater is aerated to encourage the growth of microorganisms, and organic pollutants in the wastewater are broken down by biochemical oxidation performed by the microorganisms. With this method, however, there is a limit to the concentration of microorganisms in the reaction tank, and treatment capability of the system is limited by the volume of the tank.

This treatment tank is called an "Encapsulated Carrier Fluidized Bed Treatment System," and it utilizes fixation by microorganisms, which is one of the methods of biotechnology.

There are two types of fixation processes: the encapsulation fixation process in which the active microorganisms used for wastewater treatment are encapsulated within polymer materials at high concentrations, and the bound fixation process in which the microorganisms are mainly bound to inorganic materials. The encapsulation fixation process utilizes microorganisms held within capsules at high concentrations, whereas the bound fixation process introduces substances such as stones, sand, and activated carbon into the reaction tank, and the microorganisms attach themselves to their surfaces and grow. These processes provide faster and higher quality treatments because the microorganisms can be maintained at high concentrations.

Encapsulation fixation is used in the system developed by Kumagai Gumi because of its simplicity and the high effectiveness of the fixing microorganisms.

In the past, acrylamide and agar have been used as fixation materials (carriers), but the company developed a cube-shaped polyolefin in-house that has greater porosity and better wastewater permeation than other polymer carriers. It is also easy to manufacture. Although polymer carriers have been used in fermentation and drug production, this is the first case in which they have been used in a wastewater treatment system. Initial startup of the system is rapid, and the polymer is resistant to variations in the volume and quality of the influent, so the quality of water after treatment is stable. Moreover, to increase the contact efficiency with the polluted water, the system uses air to agitate the carriers, and a fluidized bed with air lifts for circulation.

The stage after the fluidized bed in this system is a contact aeration tank, which utilizes the additional effectiveness toward suspended sediment of films of organisms adhering to the contact material and cuts down on phenomena such as the white clouding of treated water by the outflow of fine SS.

Because the concentration of microorganisms is so high, the system offers increased wastewater treatment capability per unit volume, and this allows for a reduction in surface area of 25 percent in a facility designed to handle 100 m<sup>3</sup> of effluent per day. The system can be built partially or totally underground, which contributes to the preservation of the surrounding environment by reducing noise and vibration, offensive odors, and unsightly structures.

Because this system employs an anaerobic fluidized bed with encapsulation fixation carriers and a contact aeration tank in a two-step treatment process, it produces treated water with BOD and SS levels of less than 10 mg/L without the need for high-level treatment processes such as a final-stage tertiary treatment. It achieves a treated water quality as good as existing high-level treatments such as sand filtration. This enables construction costs 15 percent lower than those of previous treatment facilities.

Because the day-to-day operation of the system is automated, no operators are needed, and maintenance is very simple.

The first unit will be installed for wastewater treatment at the clubhouse of the Konan Bird Lake Country Club in the village of Konan, Saitama Prefecture. It is designed to treat the wastewater from 378 people, or an average wastewater volume of about 75.6 m<sup>3</sup> per day. Because the system does not conform to structural standards of previous human excrement treatment tanks, the company has obtained a specific evaluation from the Japan Building Center for its practical application.

#### **Japanese Government, Companies Urge Research To Develop Rice With Recombinant DNA**

94FE0786F Tokyo MAINICHI SHIMBUN in Japanese  
23 Jun 94 p 2

[Text] "Gene recombination enables us to obtain successful results in a much shorter time than with the old methods of repeated mating, and it offers a much wider scope for improvements," says Mikio Tsunasawa (Planning Director, Biotechnology Division, MAFF). At present, research conducted by MAFF has made the most progress in gene recombination of rice. Seedlings of "Nihonbare" and another variety of recombinant rice were planted in Ibaraki Prefecture in May and June. This is the first instance in Japan in which recombinant rice has been planted in outdoor plots. MAFF will harvest the rice in October to see if the genetic properties are expressed in a natural environment, determine the size of the yield and so on.

The culture rooms at the National Agricultural Research Center (Tsukuba City, Ibaraki Prefecture) are maintained at 25°C and 3000 lux of illumination. Young seedlings of "Nihonbare" and other varieties are growing nicely in glass bottles and Petri dishes on shelves. They are samples that are used in gene recombination and tissue culture experiments.

The gene that codes for a protein on the coat of the virus that causes rice stripe disease was inserted into the recombinant "Nihonbare," which was developed by the Center and MAFF's National Institute of Agrobiological Resources, in order to give it disease resistance.

The walls of the rice cells are dissolved with an enzyme, small holes are formed in the naked protoplast membranes with electroporation, and the DNA from the virus gene enters the cells. Thus the virus gene becomes incorporated into the rice DNA, and the rice develops resistance to the disease just as a person who has been vaccinated becomes resistant.

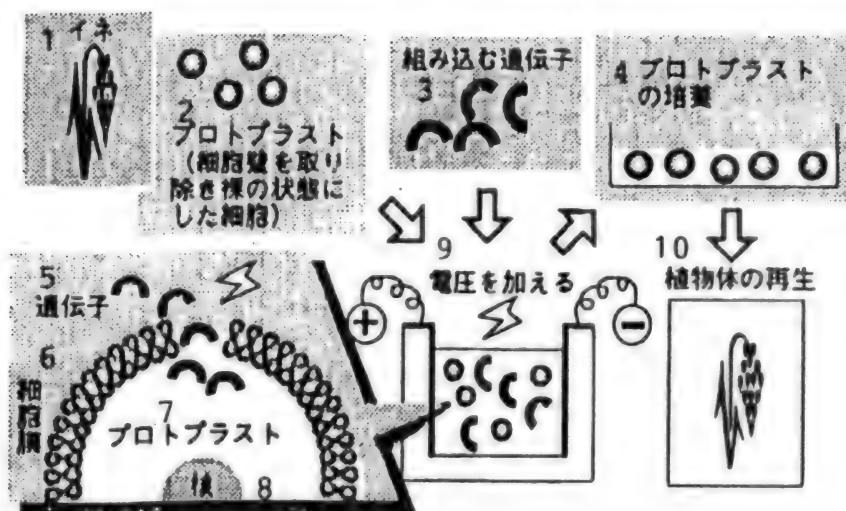
The laboratory conducts trial culturing in three stages. The first two stages are to make sure that the recombinant rice will not grow abnormally when planted in soil and that it will not cause other plants to wither. This year the rice reached the final stage, "culturing in open plots."

Akira Wakasa (Director, Breeding Engineering Laboratory, National Agricultural Research Center) says, "The cultures have not produced enough rice to cook and eat, so we still do not know how it tastes." He goes on to emphasize, "If Nihonbare is successful, we can create rice that is not only resistant to disease but also tastes good. Right now the most important goal is to find useful genes for practical applications."

The development of new commercial products through gene recombination is proceeding in the private sector as well. Mitsui Toatsu Chemicals, Inc. (Chiyoda-ku, Tokyo) is developing recombinant rice that does not produce allergenic proteins and rice with a gene to suppress amylose content, which should make it stick together better when cooked. Currently these rices have begun "culturing in isolated plots" as the third stage of testing.

However, many people express strong doubts about the safety of technology that manipulates genes. Some consumer groups in the U.S. have dubbed the FDA approved recombinant tomato the "Frankentomato," and complain that its effects on the human body are still unknown.

Recombinant enzymes are already used in the manufacture of cheese. The government has established a safety evaluation policy for substances such as these recombinant enzymes in which the recombinant cells themselves are not eaten. However, a spokesman from the Ministry of Health and Welfare's Food Sanitation Division says, "The current safety policy cannot adequately cover recombinant rice and vegetables. We are moving quickly to create a new policy."



Gene Recombination Method (for National Agricultural Research Center's 'Nihonbare')

Key: 1. Rice 2. Protoplast (A cell in which the cell wall has been removed) 3. Gene for recombination 4. Protoplast culture 5. Gene 6. Cell membrane 7. Protoplast 8. Nucleus 9. Voltage applied 10. Propagation of whole plant

Setsuko Yasuda (Director of Food Issues, Consumers Union of Japan) states, "The government's position is that if the content of the product is the same, there is no problem even though the production process may differ, but with today's gene manipulation technology there is no guarantee that unexpected consequences will not occur. It is dangerous to rush into development and policy-making without conducting animal experiments. We need more involvement by the general citizenry."

MAFF responds by saying, "Recombinant rice has cleared the governmental policies for recombinant plant culturing tests, so there is no danger that it will adversely affect the ecosystem." Mr. Wakasa says, "I believe the Nihonbare we are working on is safe. There is no guarantee that recombinant techniques are 100 percent safe, but it is also dangerous to use pesticides to prevent crop loss. I think it is a matter of finding a good balance."

#### Chugai Pharmaceutical Co., U.S. Bio-Venture Company Agree To Jointly Develop Anti-Sense Pharmaceuticals

94FE0786G Tokyo NIKKEI SANGYO SHIMBUN  
in Japanese 24 Jun 94 p 19

[Text] On 23 June, Chugai Pharmaceutical Company announced that it had formed an affiliation with the U.S. bio-venture company Targetech (located in Connecticut) for research on antisense drugs for hepatitis B. Antisense drugs have attracted attention as next-generation drugs for treating illnesses on the genetic level, and recently many Japanese pharmaceutical makers have jumped on the joint research bandwagon with U.S. bio-venture companies.

According to the terms of the agreement, Chugai will supply research funds to Targetech, and when promising therapeutic substances for the treatment of hepatitis B are developed, Chugai will receive sole clinical development and sales rights in the four regions that include Japan, ROK, PRC, and Taiwan.

According to Chugai, Targetech has the technology for introducing antisense drugs and genes into liver cells via specific receptors located on their surface. The two companies will jointly develop the hepatitis B antisense drugs using this technology.

An antisense drug works by binding to messenger RNA, which carries information copied from the DNA that makes up a gene, and blocks its function. Hopes are that the practical application of antisense drugs will provide cures for cancer, AIDS and other illnesses on the genetic level.

Among Japanese pharmaceutical companies, Eisai Company Ltd. is jointly developing an antisense drug for cytomegalovirus (CMV) retinitis, which often attacks AIDS patients, with the U.S. company ISIS (located in California), and the world's first clinical tests are underway to determine its effectiveness in humans.

#### Japanese Company, U.S. Bio-Venture Company Agree To Jointly Conduct Genetic Screening

94FE0786H Tokyo NIKKEI SANGYO SHIMBUN  
in Japanese 23 Jun 94 p 17

[Text] On 22 June, the clinical screening company Health Sciences Research Institute (Yokohama) announced an alliance with the U.S. bio-venture DIANON Systems (located in Connecticut; John Davis, president) for the purpose of genetic screening. The Health Sciences Research Institute will act as a liaison in Japan for DIANON, which has the technology for determining paternity and for diagnosing congenital illnesses.

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The Health Sciences Research Institute will begin providing these screening services to medical organizations such as hospitals in the near future. In addition, the companies plan to establish a genetic screening joint venture company in Japan around 1996 after completing a survey of the market.

The Health Sciences Research Institute conducts genetic screening for congenital illnesses such as sickle cell anemia, Huntington's disease, fragile X chromosome syndrome, muscular dystrophy and so on. Detection of genetic abnormalities makes it possible to determine the risks of developing a disease before symptoms of the disease appear or in fetuses before birth. The company will also provide a service for determining paternity by genetic analysis.

The Health Sciences Research Institute will send samples of screening participants' blood to DIANON and report back on the results. It also has plans to set up a network of specialists to provide counseling services to screening participants.

The companies plan to conduct a market survey in Japan based on the orders they receive and to establish a joint venture in 1996 with each company contributing half the capital. DIANON will provide the screening techniques, and the new joint venture will set up an organization for conducting genetic screening in Japan.

DIANON is a thriving venture company with an excellent track record in genetic screening for cancer and congenital diseases. In the U.S. genetic screening is widely conducted on fetuses before birth to determine whether they have inherited a congenital disease and on patients who have yet to develop disease symptoms to determine whether they are at risk.

In Japan, on the other hand, several companies are performing screening, but the size of the market has not been studied in detail. For most congenital diseases there is no cure, and doctors are divided in their opinions concerning the benefits of this kind of diagnostic screening.

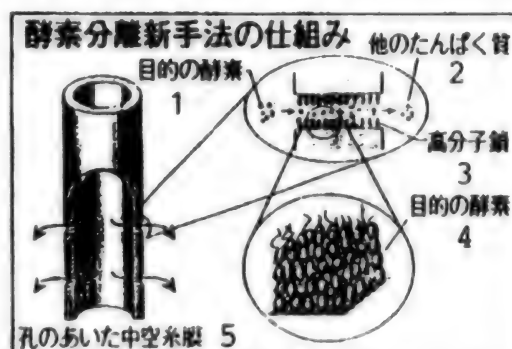
#### U of Tokyo, JAERI Develop Efficient Method To Separate Enzymes

94FE07861 Tokyo NIKKEI SANGYO SHIMBUN  
in Japanese 23 Jun 94 p 5

[Text] A research group from the University of Tokyo's Faculty of Engineering and JAERI's Takasaki Radiation Chemistry Research Establishment have developed an efficient method for separating enzymes and other proteins dissolved in aqueous solutions. The group created a prototype enzyme separation device that consists of a system of tube-shaped porous membranes that have chains of polymers arrayed around the pores. The group confirmed that the device enables separation, adsorption and easy recovery of large quantities of enzymes in short periods of time. They expect the device to help in the

separation and purification of useful proteins, an essential technique in the development of new drugs and other kinds of research.

The group that developed this new method was led by professor Shintaro Furusaki of the University of Tokyo and assistant professor Yukikazu Saito (currently at Chiba University).



New Enzyme Separation Method

Key: 1. Desired enzyme 2. Other proteins 3. Polymer chain 4. Desired enzyme 5. Hollow membrane with pores

The research group used hollow polyethylene membranes with an outside diameter of 3mm and 0.3  $\mu$  pores. The group exposed molecules of glycidyl methacrylate to an electron beam to polymerize it and grew polymer chains at the peripheries of the pores. Then they replaced a portion of the polymer with molecules that bind the proteins ionically.

When the group introduced an aqueous solution of urease, an enzyme that breaks down urine, into the tubular membranes under pressure, the enzymes adhered with high efficiency to the chains around the peripheries of the pores as the solution passed through. Because a single polymer chain can bind several enzymes, the quantity of enzyme adsorbed was 56 times greater than when the system of tubular membranes was used without the polymer.

To recover the adsorbed enzyme, the researchers merely introduced an aqueous solution with a high salt concentration into the membrane tubes. This weakened the ionic bonds between the enzymes and polymer chains, and released the enzyme. The recovered enzyme showed about the same high levels of reactivity as it did before it was adsorbed. Urease was used in these experiments, but it will be possible to separate antibodies and other enzymes merely by changing the substituted molecules on the polymer chains.

The next research topic will be to study whether it is possible to isolate a desired protein from a solution containing many different proteins. The research group

is hoping that their method can be used as a means for isolating useful proteins from liquid culture media for cells and plasma.

An earlier method for isolating proteins utilizes beads with small pores. Because the previous method involves waiting for the enzymes in the solution to diffuse through the pores, it requires much more time than this new method in which the protein solution is forced through the membrane by pressure.

#### **Marine Biotechnology Institute Starts Research on Astaxanthin for Industrial Use**

94FE0786J Tokyo KAGAKU KOGYO NIPPO  
in Japanese 20 Jun 94 p 4

[Text] A group at the Marine Biotechnology Institute (MBI) led by Akihiro Yokoyama have confirmed the production of the red pigment astaxanthin in marine bacteria. Studies have been made concerning the practical application of this substance, which is obtained by organic synthesis and also from natural sources such as krill and red yeast. This is the first time it has been found in bacteria. It is hoped that this discovery will pave the way for technology to mass produce this substance by fermentation and other methods.

Astaxanthin is a type of carotenoid similar to  $\beta$ -carotene, which has recently become a hot topic. It has been used in the past as a substance to enhance the color of red sea bream, but recently scientists have discovered that it acts as an antioxidant and suppresses the growth of tumor

cells. Therefore, it has potential uses not only in foods but also in pharmaceutical products.

The group discovered bacteria that produce carotenoids such as  $\beta$ -carotene from among the marine bacteria collected by the MBI research vessel "Sogen Maru" in 1990 and 1992. They found that the marine bacteria *Agrobacterium aurantiacus* that was collected from the surface layers near the Kerama Islands produces astaxanthin with relatively high efficiency. In the past, Japanese and foreign companies have conducted a considerable amount of research toward practical application of astaxanthin, not only the synthetic version but also that extracted from natural sources such as Antarctic krill, the algae *Haematococcus* and *Chlorella*, and the red yeast *Phaffia*. However, this is the first confirmation of astaxanthin production by bacteria.

Mr. Yokoyama's group cultured the *Agrobacterium aurantiacus* in liquid media, and after collecting the bacteria by centrifugation, isolated its various constituents by chromatography and other methods. They obtained yields of 0.09 mg of astaxanthin and 0.33 mg of 4-keto-zeaxanthin per liter of culture media. The group also studied the chemical structures of astaxanthin's synthetic precursors and obtained a new understanding of the synthetic pathway from  $\beta$ -carotene to astaxanthin.

Based on modifications in culturing conditions and the new knowledge of the synthetic pathway, the group will proceed with joint research toward the development of mass production technology such as fermentation. It is expected that applications for  $\beta$ -carotene and other carotenoids will become widespread in the future, so the progress of this research will be watched closely.



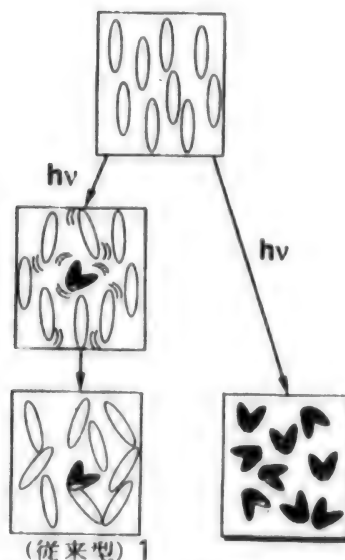
# Tokyo Institute of Technology Develops New Liquid Crystal for Photonics

94FE0787A Tokyo KAGAKU KOGYO NIPPO  
in Japanese 20 Jun 94 p 10

[Text] Assistant professor Tomiki Ikeda (Resource Chemistry Research Institute, Tokyo Institute of Technology) has developed a liquid crystal photonics material that responds at the ultrahigh speed of less than 200  $\mu$ sec. The material was developed as part of the research in the "Light and Materials Field" of The Innovative Individual Research and Training Project (The Precursory Research for Embryonic Science and Technology Program) under the auspices of the Research Development Corporation of Japan. This material realizes a huge increase in optical phase transition speed, shortening the previous speed of 50 millisecc by more than 100 times. Until now, 50 millisecc was considered the limit for optical phase transition speed. Liquid crystal photonics materials are expected to perform as next-generation optical memory elements and as optical operators in data processing. Development has proceeded on two systems, nematic liquid crystals that employ optical phase transition, and ferroelectric liquid crystals that employ optical polarity transition. Assistant professor Ikeda has developed a material based on an entirely new principle, and it greatly increases the potential for practical applications of nematic liquid crystal systems.

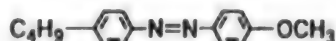
The nematic liquid crystal photonics material developed by assistant professor Ikeda is based on an entirely new principle. Previous nematic liquid crystal photonics materials achieved phase transition by using high polymer liquid crystals and low polymer liquid crystals as hosts, doping them with photochromic molecules such as azobenzene as guests, combining them, and utilizing the changes in molecular shape resulting from trans-cis isomerization. Although the trans-cis isomerization was achieved in picoseconds with this system, the actual optical response time of the material was limited to 50 millisecc.

Assistant professor Ikeda built photo-responsive members into the liquid crystal molecules so that the molecular shapes of all the liquid crystals are altered, and there is as little loss as possible in the speed of trans-cis isomerization. This improved the performance properties of the liquid crystal photonics material, enabling a large increase in speed. Assistant professor Ikeda developed 4-butyl, 4-methoxyazobenzene (BMAB) as the liquid crystal molecule incorporating the photo-responsive member. He created an optical modulating material by forming a 100 nm thin film of polyvinyl alcohol (PVA, POVAL) on a glass substrate that had been treated by rubbing. He illuminated this with 355 nm pumped light in 10 ns pulses, and he confirmed that the optical phase transition was occurring at the ultrahigh speed of less than 200  $\mu$ sec by observing the changes in probe light transmittance. He also confirmed that it was possible to achieve phase transitions of less than 200  $\mu$ sec with 8AB8, a compound in which an



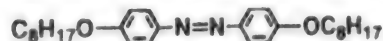
Conceptual Drawing of Liquid Crystal Drive Based on New Principle

Key: 1. (Past forms)



BMAB

K 32 N 42 I



8AB8

K 99 N 113 I

Nematic Liquid Crystal Containing Photo-Responsive Member

octyl alcohol is attached to each end of the azobenzene molecule, and with polyacrylate that has azobenzene side chains.

Photonics, which utilizes photonic processes instead of electronic processes, is expected to be used in the next-generation of information processing equipment and computers, so development of non-linear optoelectronic materials is well underway. Among these, liquid crystal photonics materials will enable the creation of switches, circuits and functional elements that use light-light responses. The development of photonics materials has centered around nematic liquid crystals and ferromagnetic liquid crystals. The new photonics material developed by assistant professor Ikeda offers advantages over ferromagnetic liquid crystals, which are structurally complex, and we can expect it to be the main target of future development. Assistant professor Ikeda will continue working on the development of materials that respond in nanoseconds and picoseconds, with an ultimate goal of femtosecond response times.

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### Sanyu Corporation Develops New Laser Technology for Micromachines

94FE0787B Tokyo NIKKEI SANGYO SHIMBUN in Japanese 6 Jul 94 p 1

[Text] The Sanyu Electronics Corporation, a maker of equipment for electron microscopes, has developed a YAG laser fabricating machine that utilizes a semiconductor laser as its excitation light source. The YAG laser wavelength is first shortened to 266 nm, one-fourth its conventional wavelength, with a semiconductor laser, and this enables it to be used for machining of micromachines and other miniature devices. Until now excimer lasers have been used in micromachining systems. Although excimer lasers have high output, they also have drawbacks such as troublesome maintenance because they use gas. Because running costs are reduced by using a semiconductor laser, the company plans to sell this machine to research facilities and similar organizations.

The newly developed machine is the SLM-700, a semiconductor laser-excited YAG laser fabricating machine [photo not reproduced]. The machine shortens the laser output wavelength to 266 nm, which allows the machining focus to be narrowed to 1  $\mu$ m. Because this increases the light absorption of the material to be processed, machining is possible with as little as about 0.1 W of energy. Because the gas replacement operation is no longer necessary and the laser cooling system is simpler, this new laser has running costs less than one-tenth those of an excimer laser system.

With the wavelength set at 266 nm, the photonic energy of the laser is increased to 700 kilocalories. This is enough to break the molecular bonds of polyethylene and vinyl chloride, and it offers improved machining precision because the softening that accompanies machining by melting is eliminated. Because a variety of machining methods is required in micromachining, the device offers three wavelength settings of 355 nm, 532 nm and 1064 nm.

The new machine is a desktop model with dimensions of 90 cm L x 31 cm H x 22 cm W. The cost is about ¥ 10 million when combined with its peripherals into a system. The company plans to market the machine mainly to micromachining technology research organizations in universities and businesses, and it expects to sell about 10 units the first year.

Excimer lasers, which are generally used as laser fabricating tools for micromachining, feature high output at low wavelengths. They are suitable for mass production, and the development of such systems is underway in precision machine-related industries.

#### Sanyu Electronics

Sanyu Electronics is a venture company that manufactures and sells peripheral devices for electron microscopes. Since its establishment in 1976, the company has manufactured specimen surface treatment devices and

measurement systems that measure the specimens every few nanometers and draw three-dimensional images of them. The company began its laser equipment business last year. The company is developing products specifically for research organizations rather than for mass production. Gross sales in 1993 were ¥ 350 million.

### STA Reports Trends in Import of Technology Related to Nuclear Power

94FE0787C Tokyo GENSHIRYOKU SANGYO SHIMBUN in Japanese 19 May 94 p 5

[Text] The National Institute of Science and Technology Policy (NISTEP), an auxiliary organization of the Science and Technology Agency, has released a report that analyzes the trends in the import of foreign technology for FY92. The figures and analysis are based on the "Written Reports Concerning Technology Import" as stipulated in the "Order Concerning Direct Investments in Japan," which is based on the "Foreign Exchange and Foreign Trade Control Act."

According to the report, there were 3,224 instances of new technology import during FY92, an increase of 1.5 percent over the previous year. The trend of more than 3,000 instances annually has continued over the past three years, and 80 percent of these cases represent know-how. Moreover, there were 1,624 cases of computer software import, which accounts for more than half the total imports. When broken down by nation, imports from the U.S. are an overwhelming 65 percent of the total. This is followed by the UK with 221 instances (amounting to 7 percent of the total).

There were 75 instances related to nuclear technology, down 12 percent from the 85 instances of the previous year. However, the figures over the past few years have remained nearly constant.

Details of imported nuclear technology by type of technology include the following:

#### Non-Ferrous Metals

- Technical information concerning nuclear fuel, mainly dry reprocessing technology;
- Technology concerning MOX fuels;
- Design information and patent licenses concerning BWR replacement fuel assemblies (Step II).

#### Boilers and Power Reactors

- Technology for evaluating soundness of jet pumps and shrouds, which are BWR in-core structures;
- Reliability verification tests for ABWR main steam separation valves and safety release valves;
- Basic tests under neutron exposure environments in PWRs;
- Technology concerning main equipment in German LWRs;
- Technical information concerning HTTR core design, reactor system, and utilization system;
- Technology to reduce human error in maintenance and repair operations in nuclear power plants;

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- In-core tests for the release of fission products and reactor damage during reactor accidents;
- Technology concerning steam generator fabrication;
- Technical support concerning design, fabrication, and use of PWRs;
- Technical information concerning detection of steam generator leaks in FBRs;
- Research on SCC of materials due to neutron exposure;
- Technology for HTTR shielding analysis;
- Study concerning design simplification and cost reduction of FBR reactor system and fuel system;
- Technical information concerning FBR operation experience in Russia;
- Technology concerning earthquake-resistant designs for nuclear power plants;
- Test data concerning natural circulation heat removal of FBR direct core cooling system;
- Technology concerning fabrication of steam generators and their auxiliary equipment;
- Consignment of research concerning control of radioactive nitrogen for water quality;
- Receipt of technology assessment by BWR owners group;
- Technology concerning extension of PWR life;
- Technology concerning BWR in-core recombiner;
- Reliability verification tests of improved ABWR control rod drive device.

#### Chemical Machinery and Equipment

- Technology concerning materials data on reduced-pressure steam process for reprocessing plants;
- Technology concerning stochastic safety evaluation of reprocessing equipment;
- Dry reprocessing technology concerning recycling of actinide elements from LWR spent fuel;
- Manufacturing and design engineering for reprocessing;
- Processes and equipment for manufacturing radioactively labelled compounds;
- Technical information on systems for handling containers for transporting spent fuel.

#### Computers

- Tools for nuclear power plant education and public relations;
- Programs for nuclear power plant earthquake hazard analysis;
- PWR core control codes;
- Optimal evaluation codes for heat flow analysis;
- Stochastic safety evaluation software for nuclear facilities;
- Accident simulation software;
- Software for graphic processing of computational results of safety analysis codes;
- Evaluation and analysis software for use during accidents;
- Simulation software for research on human factors.

#### Other

- Operation and maintenance technology for German LWRs;
- Studies and compilations of foreign data concerning technology for non-destructive testing and evaluation of nuclear power plant equipment;

- Technical information concerning nuclear power plant operation;
- Nuclear medicine equipment;
- Technology concerning digital X-ray imaging and diagnostic methods.

#### Sumida Optical Glass, Ltd. Develops New YAG Radiation Conversion Crystal

94FE0862A Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 26 Jul 94 p 6

[Text] Sumitomo Optical Glass (address: 4-7-25 Horigaya, Urawa-shi; president: Mr. Masatoshi Sumita; Tel: 048-832-3165) has developed an infrared ray checker, designed to convert normally invisible YAG laser light into visible rays by using fluorescent crystallized glass. Although similar products made of opaque ceramic have been available commercially, these products have not been able to handle high output light. Practical use of this type of product made of fluorescent crystallized glass, therefore, is said to be the world's first.

Although YAG lasers are used widely in machining as well as medical and research fields, since laser light wavelength of 1.06 microns is outside the infrared zone, it is not visible, making it extremely difficult to adjust and position optical axis. For this reason, an infrared ray checker, designed to convert invisible rays into visible types, is used.

At present, commercial products regarded as the "mainstream" are those of opaque ceramic produced by baking fluorescent powder. Those, however, are unsuitable for use in the minute observation of beam mode as well as quantitative changes in light. Also, they lack the ability to perform three-dimensional observations. Moreover, since their damage threshold for output light was small, it was not possible to use them for high output laser light.

The newly developed product, on the other hand, is made of transparent fluorescent crystallized glass formed by precipitation in the host oxide glass of fluorescent microcrystals which can be converted into infrared rays (wavelength range: 0.9 - 1.07 microns) with high efficiency. As such, it will be useful in the observation of YAG lasers.

#### Tokin Corporation Develops Smallest Optical Coupler for Fiber Optical Communication

94FE0862B Tokyo NIKKAN KOGYO SHIMBUN  
in Japanese 9 Jun 94 p 1

[Text] Tokin Corporation (president: Mr. Tomihiro Matsumura) has developed the world's most compact optoisolator measuring 4 microns in diameter. Its use for a 0.98 micron wavelength band produces excellent light excitation efficiency. The optoisolator is an electronic part essential to improve the performance of light amplifiers in fiber optic communication networks. In the



United States, a country with advanced optic communication technology, only 0.98 micron wavelength amplifiers are being used; however, the practical use of optoisolators with the same wavelength has yet to be achieved. This is the first time a small optoisolator which contributes to producing a compact-size amplifier main unit has been developed. Beginning in October, it will be mass produced at Shiraichi Plant (Miyagi Prefecture), where automated manufacturing facilities will be implemented at the same time. The company is estimating the first year's sales to reach a few hundred million yen. With the expansion of the multimedia market, the company is projecting the sales to rise above ¥10 million after two years.

The optoisolator with a diameter of 4mm will be configured into direct optic amplifiers at low cost. By developing the unique crystalline material, the company has succeeded in developing the optoisolator with a small diameter. Last year, Tokin developed a 0.98 micron product with a 9-mm diameter. The company, however, was targeting for the 4-mm diameter product, which will meet the optic communication system package standard. For crystals, CdMnHgTe, a compound produced by adding mercury to cadmium manganese tellurium. It is characterized by low noise, lower than that of the 1.48-micron wavelength product used as a substitute of the 0.98-micron product, and low power consumption halving the amount of power consumed by excitation light source. The reason why the company used the high-efficiency 0.98 micron wavelength was to respond to the need of large volume communication systems while reducing amplifier costs by lowering noise levels and consumption of electric power.

#### **Tokyo University Develops New Quantum Box Laser**

943FE0862C Tokyo NIHON KEIZAI SHIMBUN  
in Japanese 18 Jun 94 p 12

[Text] Tokyo University's Institute of Industrial Science research team led by Professor Yasuhiko Arakawa has succeeded in developing the world's smallest semiconductor structure known as a quantum box which is essential to the realization of high-performance lasers and other next generation semiconductor devices. Utilizing the principle of materials forming particles through natural agglutination process rather than forced processing, the research team produced hemispherical structures measuring no more than 1/100000mm in diameter. Their use in achieving low-cost mass production of future optic computers, high-performance lasers employed in communication equipment, and memory devices is creating expectations.

The quantum box is a micro structure created inside a semiconductor. The smaller the structure the higher the electron containment efficiency. Electrons play a vital role in light emission and storage and transmission of information. In order to create devices which can operate at room temperatures, a processing technology designed to limit the size of a quantum box to below 15

nanometers (1 nano is 1/1 billion) will be required. The existing boxes measured as much as 30 nanometers.

The dimensions of the quantum box produced by the company: main unit diameter = 12 nanometers; bottom part diameter = 15 nanometers; height = 7 nanometers. The small structure made it possible for the company to achieve the 100-billion-elements-per-1-cm<sup>2</sup>-substrate level super VLSI without sacrificing uniformity.

#### **Toshiba Corporation Develops High Output Red Semiconductor Laser for High Density CD Recording**

94FE0862D Tokyo NIKKEI SANGYO SHIMBUN  
in Japanese 15 Jun 94 p 8

[Text] Toshiba has developed a visible red semiconductor laser for high density CD recording. Shipment of samples will begin on June 14. In the past, because of its low level light output, the red semiconductor was regarded as unsuitable for optic disk recording. Toshiba has developed a unique method designed to improve the red laser's output performance. Its sample is priced at ¥150,000, and the company will begin mass producing at the rate of 60,000 per month by the end of this year.

The new product is a laser with short wavelengths measuring no more than 685 nanometers (1/1 billion). It was possible to achieve the same level wavelength with existing red semiconductor lasers. However, since the minimum output of 50 mW required for recording could not be generated, their use has been limited to bar code readers of POS systems.

By applying a special design to the red laser's light-emitting active layers, Toshiba was able to raise the level of light output at the time of recording.

#### **Japan Optoelectro-Mechanics Association Develops New Atomic-Level Laser Processing Technology**

943FE0862E Tokyo KAGAKU KOGYO NIPPO  
in Japanese 12 Jul 94 p 1

[Text] Japan Optoelectro-Mechanics Association, a foundation, has put together a report concerning laser processing technology. Recently technologies designed to work with materials at molecular and atomic levels have been attracting interest; however, those technologies can control only a very minute area. Pointing out the need for the type of technology designed to capture light as photons and control wide areas at molecular and atomic levels using lasers, the report proposes a national project. Responding to the proposal, the Ministry of International Trade and Industry (MITI) is now studying the subject as a new theme for the 1995 cutting-edge research.

The report was prepared by the association's Laser Processing Technology Committee. According to the report, although approximately 60 percent of precision metal cutting is performed by lasers, in welding, such factors as changes in light reflection index, the generation of plasma at

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the time of processing, and welding cracks, presented problems. Moreover, in hardening steel, a drastic temperature change will result in quenching crack.

That is why a molecular and atomic level laser processing technology will be required. Atomic/molecular-level-processing technology, which in recent years has been attracting attention, was already used in the development of scan tunnel microscope (STM) and atomic force microscope (AFM). In comparison with it, the laser processing technology is capable of irradiating far greater areas and therefore is more suited to mass production.

The report maintains that, in addition to R&D of optical systems, including laser processing and photon measurement technologies, a high-grade and high-output laser oscillator must be developed. Moreover, since high output lasers are a large scale product, it will

be necessary to develop optic fibers which will introduce lasers into plant floors, as well as portable LD excitation lasers.

Since over 50 percent of the entire world's laser processing equipment is installed in Japan, Japan is recognized as an advanced country in the laser processing technology field. However, the United States and Europe have begun intensifying their R&D efforts in this field so that they can overtake Japan. Although they are competing fiercely to gain the Japanese market share, none of their efforts can yet to be described as a well-organized move. Japan, therefore, must organize a national project, marshalling laser, optical element, and optochemical technologies and establishing industrial, academic, and governmental sector collaboration. The report also suggests that laser processing technology will lead to the creation of new high-tech industries.



**Commercial Operation of Shika Nuclear Power Station**

43070203A Tokyo HITACHI TECHNOLOGY 94  
in English Jun 94 p 31

[Text] Construction of Unit No. 1 of the Shika Nuclear Power Station was completed and commercial operation began on July 30, 1993. Steady operation continues at Shika, the first nuclear power station of the Hokuriku Electric Power Company. It is located on the beautiful west coast of the Noto Peninsula.

Site area is about 1.6 million square meters. The intake/heat-exchanger building, turbine building and reactor building are arranged in a straight line pointing away from the sea. A service building and a waste treatment building are independently located opposite each other.

The sea structures such as the offshore intake structure, landing pier, and connection bridge are designed so as not to alter the tide flow around the nearby beach area. The plant structures were designed to harmonize with the natural surroundings.

The Shika Station has a long history. In November, 1967, Hokuriku Electric first announced its intention to build the facility. After a series of land purchase negotiations, environmental assessments, and public hearings, construction finally began in December 1988.

Construction progressed on schedule starting with bedrock examination by MITI in May 1989. The reactor pressure vessel was set in place in August 1991, and the first fuel loaded in November 1992. After the fuel loading, start-up tests were conducted and the plant was turned over to Hokuriku Electric Power Company in July 1993.

The power station is a boiling-water type light-water reactor of 540 megawatts electrical output with an improved MARK-I type primary containment vessel. The most advanced technologies based on MITI's Improvement and Standardization Program for Light-Water Reactors and the experience obtained from the design of other plants were utilized to create the plant.

The new technologies utilized include Step-I fuel for high fuel burn-up, advanced control system man-machine interface with CRTs, enhanced automatic plant operation, digital control and instrumentation systems, inverter speed control of the recirculation pumps, and a cement-glass radioactive waste solidification system.

Three-dimensional computer aided plant arrangement, piping design, and fabrication were fully adopted.

Hitachi and its subcontractors achieved a record of zero human injuries throughout the construction and start-up period. This was another great achievement in Shika Station construction. These good results were made possible through excellent cooperation among the site construction team members including Hokuriku Electric Power Company.

**Hamaoka Nuclear Power Station Unit No. 4 Commercial Operation Started**

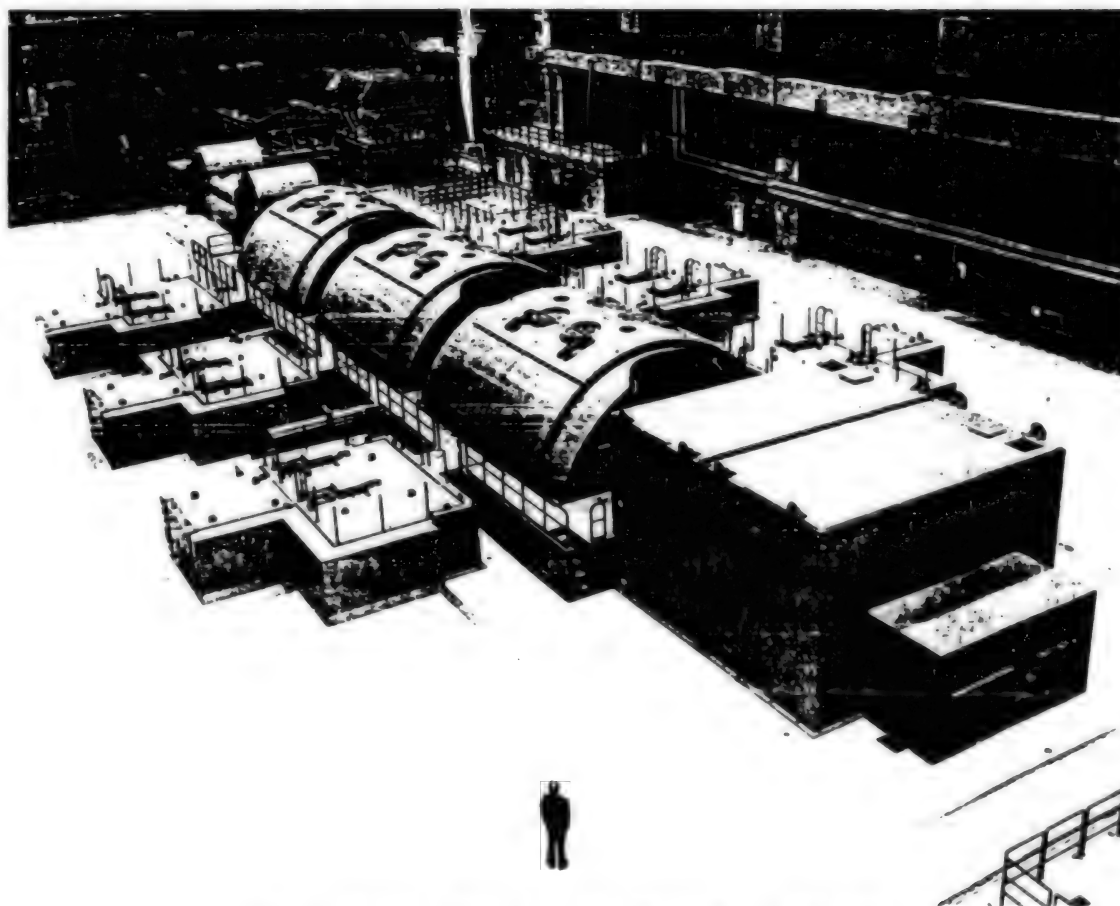
43070203B Tokyo HITACHI TECHNOLOGY 94  
in English Jun 94 p 32

[Text] Chubu Electric Power Co., Inc. Hamaoka Nuclear Power Station Unit No. 4 (H-4) started commercial operation on September 3, 1993. Satisfactory operation of H-4 with the expected high performance has continued since then. H-4 has the largest electrical output, 1,137 MWe, among boiling water reactors (BWR) in Japan.

Many of the newest technologies are incorporated in H-4. A moisture separator heater (MSH) and reheat cycle system, which is used for the first time in a BWR in Japan, makes a large contribution to increasing electrical output and higher plant efficiency. The hollow-fiber filter in the condensate-purification system provides excellent performance in removing crud in the condensate water and in reducing radioactive-waste generation. Digital technology improves both the man-machine interface and maintainability of the individual systems of the plant. The new technologies make for improvements in reliability, maintainability, cost efficiency, and operability.

Construction was completed in 48 months—from completion of bedrock examination to start-up of commercial operation. This construction period is the shortest on record for a nuclear power plant of this scale. Hitachi, Ltd. and its group also achieved the remarkable record of zero labor accidents through the full construction period.

During initial test operation, all operating tests were carried out according to the planned schedule. All equipment and systems were carefully examined to confirm that they met design specifications, and the high reliability and performance of H-4 was verified. Chubu Electric Power Co., Inc. and Hitachi won a prize from the Japan Machinery Federation for design of the moisture separator heater as excellent economical equipment.



Turbine Room at Hamaoka Nuclear Power Station Unit No. 4

**First ABWRs: Construction of Kashiwazaki-Kariwa Units 6 and 7**

43070203C Tokyo HITACHI TECHNOLOGY 94  
in English Jun 94 p 33

[Text] The first Advanced Boiling Water Reactors (ABWR) are now under construction on schedule at the Tokyo Electric Power Co., Inc., Kashiwazaki-Kariwa Nuclear Power Station, in the northern part of Japan. At the end of April, construction was 62 percent completed for Unit No. 6 and 37.4 percent for Unit No. 7.

The ABWR was developed as the next generation BWR by the joint efforts of six Japanese utilities and three BWR suppliers—with Japanese Government support. Worldwide BWR operating experience was widely reviewed and the leading proven technologies were selected and further optimized to constitute the basis of the ABWR design.

Construction of Units 6 and 7 started in September, 1991, and February, 1992, after completion of the safety review and granting of the construction permit by the regulatory authorities. The target is to bring them into commercial operation in 1996 and 1997, respectively.

This project is being executed by an international joint venture organized by two Japanese and one U.S. BWR manufacturers. Hitachi is responsible for the Unit No. 6 turbine island and Unit No. 7 nuclear island, and acts as the *daihyosha* (representative) for Unit No. 7.

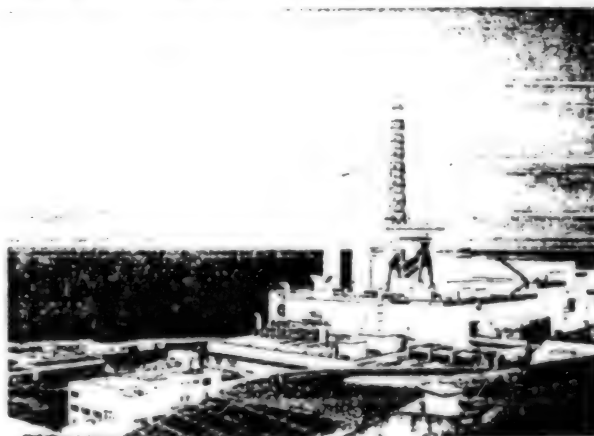
Hitachi is utilizing a super-heavy-lift mobile crane that makes possible a shorter construction period through large-scale modularization of mechanical- and civil-engineering phases. This superb method showed its power when used to install the reinforced concrete containment vessel (RCCV) liners into the buildings for both Unit No. 6 and Unit No. 7. This liner was prefabricated in the shop and assembled into large ring-shaped blocks on the ground before the lift.

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**Prototype Fast Breeder Reactor Monju**

43070203D Tokyo HITACHI TECHNOLOGY 94  
in English Jun 94 p 34

[Text] MONJU, Japan's prototype fast breeder reactor, is a 280-MWe loop-type liquid-metal cooled power plant owned by the Power Reactor and Nuclear Fuel Development Corporation (PNC). Its pre-operational test following construction was completed in December 1992. The first criticality was confirmed on April 5, 1994.



**Loop-Type Fast Breeder Reactor MONJU**

The MONJU project has been executed by PNC with participation of Japan's four major reactor manufacturers: Hitachi, Ltd.; Toshiba Corp.; Mitsubishi Heavy Industries, Ltd.; and Fuji Electric Co., Ltd. The project has been given the mission of acquiring experience through its construction and operation, thus serving as an essential step toward establishing an effective uranium utilization system.

Hitachi's scope of responsibility in the project includes blanket fuel assemblies, reactor power fine control rod assemblies and their driving mechanisms, primary reactor cooling system equipment, steam generators (superheaters), and electrical and measuring equipment.

Hitachi has completed installation and pre-operational test work without any industrial accidents during the entire period of 2,190 days—5,430,000 man-hours. Pre-operational tests were performed, with success, to verify overall functions: first in an air environment, then in argon gas, and finally in liquid sodium.

In the future, reactor physics tests and start-up tests are scheduled to be performed before MONJU is connected to the grid in power operation. These tests will be managed and performed primarily by PNC, with the close cooperation of FBR Engineering Co., Ltd. and the four reactor manufacturers.

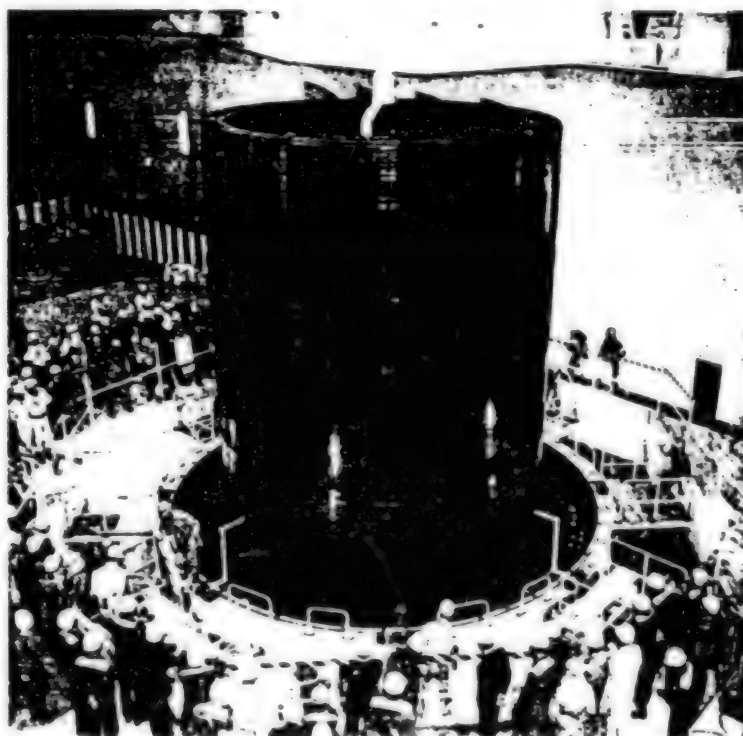
**Adjustable-Speed Pumped-Storage Power Plant With World's Largest Capacity Commissioned**

43070203E Tokyo HITACHI TECHNOLOGY 94  
in English Jun 94 p 34

[Text] The 400-MW adjustable-speed pumped-storage power plant that Hitachi, Ltd. has been developing jointly with Kansai Electric Power Co., Inc. for the Ohkawachi Power Plant has completed all tests and started commercial operation in December 1993. This power plant, the world's largest of its type, features automatic-frequency control during pumping and improved power-system stability.

Input power control during pumping for automatic-frequency control of the system is possible because an adjustable-speed pumped-storage power plant can be operated at the desired rotational speed. Newly developed control techniques for rapid power control were adopted and fulfilled design expectations. The rapid control of power is effective in improving transient stability and power-supply reliability.

Hitachi's adjustable-speed pumped-storage power plant is expected to contribute greatly to providing better quality and more reliable power. Hitachi will continue to develop larger-capacity machines running at higher speeds and featuring more compact excitation systems for a future pumped-storage plant.



Installation of Generator-Motor Rotor for 400MW Adjustable-Speed Pumped-Storage Power Plant

### Importance of Promoting Better Understanding of Japan's Nuclear Energy Policy

43070205A Tokyo JAPAN 21ST in English Jun 94 p 1

[Article by Fujio Sakauchi, Director General, Science and Technology Policy Research Institute, Science and Technology Agency]

[Text] Prime Minister Tsutomu Hata's joint news conference, telecast live on May 6 from Brussels, came as a great surprise to me because of the incredible remarks about Japan made by a Belgian reporter (The De Morgan). Taking up Japan's plutonium utilization program, she said Japan can be identified, in a way, with North Korea and asked Hata if Japan plans to scrap the program.

I assume that this sort of question is in no way surprising in itself, but what stunned me was the point that she identified Japan with North Korea. I was really dumbfounded to come across a reporter with so little common sense. Responding to her, Prime Minister Hata said, "Effective utilization of plutonium is very important to a resources-poor nation like Japan and it is also helpful from an environmental standpoint." In addition, he emphasized that Japan accepted the International Atomic Energy Agency (IAEA) safeguards to all nuclear facilities and that use of plutonium is strictly for peaceful purposes and that Japan would, therefore, continue to maintain and strengthen a more credible nuclear non-proliferation regime.

I felt an urge to ask the reporter in question what she meant when she said "in a way" in identifying Japan with North Korea. She apparently made the remark simply because Japan possesses plutonium. This reporter does not appear to know Japan restricts its use of nuclear energy to peaceful purposes and always accepts nuclear inspections by the IAEA.

Japan accepts the world's most frequent inspections of its nuclear facilities by the IAEA. About 80 officials who belong to the nuclear inspections department of the IAEA, headquartered in Vienna, are in charge of Japan, and nine of them are permanently stationed in Tokyo. It is estimated that the number of nuclear inspections Japan receives from the IAEA accounts for some 30 percent of the annual total. This means that about 2,200 to 2,300 IAEA officials are mobilized to inspect nuclear facilities in Japan each year. This substantial number of inspections reflects the diversity of operations, such as nuclear power generation, uranium enrichment and reprocessing of spent fuels, and a broad range of nuclear research activities. Details on nuclear inspections by the IAEA are not clear, but the number of domestic inspections per nuclear facility by the Japanese government is shown below. It is assumed that it almost corresponds to the number of IAEA inspections. This means, in other words, that Japan's nuclear facilities are inspected annually by a combined total of about 4,000 man-days.

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	No. of Facilities	No. of Inspections (combined total of man-days/year)
Atomic reactors	69	521
Fuel-related facilities	13	1,302
Research institutes	19	34
Others	147	4
Total	248	1,881

Of those facilities, fuel-related facilities are subject to the most frequent inspections. For example, the Tokai Reprocessing Plant receives inspections by about 700 IAEA officials per annum. In addition, cameras are installed at this plant to keep an around-the-clock watch on spent fuel pools and other major points, while enormous amounts of samples are analyzed from the important processes such as the resolution of fuel rods.

Evidently the IAEA is satisfied with all the nuclear facilities in Japan. Moreover, Japan has so far aggressively worked

together with the IAEA and other countries concerned in promoting the development of inspection-related technologies and cooperation for the prevention of nuclear proliferation, and these parties concerned fully understand Japan's position. North Korea's attitude toward IAEA inspections is totally different from Japan's stance.

I, therefore, want people in general, particularly those in the media, to understand Japan's efforts I have enumerated in the foregoing and it would be extremely annoying to have Japan still "identified, in a way, with North Korea."

For Japan, which relies on imports for more than 80 percent of its energy supplies, plutonium is a quasi-domestic energy source and the nation must continue its peaceful use.

Prime Minister Hata's press conference in Brussels has driven home to us anew the importance of promoting better understanding, both at home and abroad, of Japan's nuclear energy policy.



## Advanced Optical Fiber and Cable Technologies

43070114A Tokyo NTT REVIEW in English Jan 94 pp 65-70

[Article by Tadatoshi Tanifuji and Mitsuhiro Tateda]

[Text] High density optical fiber cable which employs a 16-fiber ribbon composed of thinly coated 200  $\mu$ m outer diameter fiber is being developed. Average optical losses of 0.2 and 0.35 dB have been attained for a 16 and an 80 single-mode multi-fiber connector, respectively. Cable jointing time has been reduced to one-fifth of that currently required. Reduction of structural imperfection loss in optical fibers is tried by matching the viscosity of core and cladding materials. The effective input optical power in optical fiber cables is enhanced as much as 7 dB by varying the Brillouin frequency shift along with their length.

### 1. Optical Fiber and Cable Technology for Future Optical Cable Network

A transmission network consists of a long distance trunk network, a regional trunk network and a subscriber network. High capacity optical transmission systems have been installed in trunk networks and these systems are more cost effective and more reliable than metallic systems. The present trunk network is designed based on analog telephone traffic. It is necessary to attain higher capacity and longer repeater spacing to support a future multi media service based on the Visual, Intelligent and Personal (VIP) concept.

On the other hand, optical transmission systems have not been fully introduced into the access network, except for leased circuits operating at bit rates above 1.5 MHz and for Central Terminal and Remote Terminal (CT-RT) systems used for multiplexing analog telephones. The present optical cable network technologies are not sufficient for the larger scale deployment of optical fiber cable to subscriber networks. High count optical cable and cable jointing technologies are both necessary in order to realize an all optical subscriber cable network.

### 2. Key Technologies in the Subscriber Optical Cable Network

This section describes our design concept for very high density, light-weight optical cables, low loss multi-fiber connectors, and pre-connecterized optical fiber cable technologies.

#### 2.1 High Density and Light-Weight Optical Cable<sup>(1)</sup>

3,600 pair cable is used in the present metallic cable network. It is considered that high count optical fiber cable containing 4,000 fibers will be necessary for the future optical subscriber cable network. The target diameter and weight for optical fiber cable currently under development is 35mm and 1.1 kg, respectively, as this will allow 1,500 m of cable to be installed in a conduit.

Figure 1 compares the diameters and weights of metallic cable, currently used optical cable and high density optical fiber cable now being developed. The outer diameter of the present 1,000 fiber optical cable is the same as that of 1,000 pair metallic cable. By developing UV curable resin whose elastic modulus is three times higher than the resin now used, it became possible to reduce the coated fiber diameter from 250  $\mu$ m to about 200  $\mu$ m. By applying the thinly coated fibers, the width of the fiber ribbons can be reduced and the number of fibers in a ribbon can be increased from the present 8 to 16. A 960 fiber optical cable is fabricated by stacking ten 16 fiber ribbons in a U-shaped groove, and by stranding the U-shaped groove around a central tension member. As shown in Fig. 1, it is possible to reduce the outer diameter by one-half and the cable weight by one-third. Figure 1 also shows 4,000 fiber cable which is constructed based on the same design concepts. The outer diameter of the cable is one-half and the cable weight is one-sixth that of 3,600 pair metallic cables.

During the transition process from a metallic to an optical cable network, conduits must be efficiently used by employing a multi cable installation technique. In such cases, the high density optical cables will play an important role.

Prototype cables have been manufactured. The loss increases during the process were within measurement

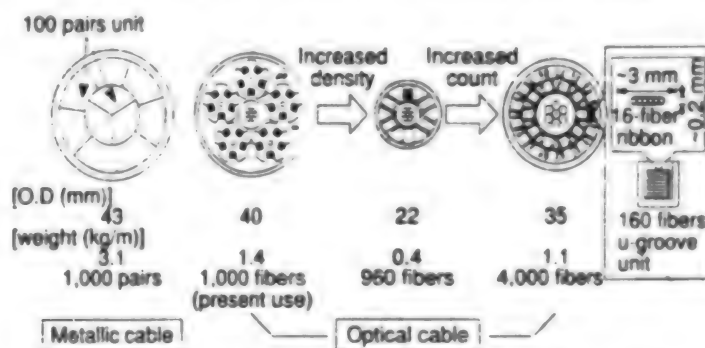


Figure 1. High Density and High Count Optical Fiber Cables

error, and the results of heat cycle and mechanical damage tests were satisfactory.

## 2.2 Multi-Fiber Connection Techniques<sup>(2)</sup>

Fusion splice and multi fiber connectors have been used alternately in joining NTT subscriber optical cable. About six hours is required to join 1,000 optical fiber cables using a four-fiber ribbon connector. This is within one working day. In order to join 4,000 fiber cables within one working day, a multi-fiber connector which can join several tens of fibers simultaneously is one of the best solutions. A reduction in the optical loss of multi-fiber connectors compared to that of a mass-fusion splice is also indispensable in order to realize a pre-connectorized cable as a replacement for fusion splicing.

Figure 2 shows the single-mode multi-fiber connectors which are now being developed. The 16-fiber ribbon connector is the basic connector. One method of increasing the number of fibers that can be joined simultaneously is to stack five 16-fiber connectors, thus forming an 80 multi-fiber connector. It will be possible to branch this connector to a 16-fiber ribbon connector. Another method is to mount 80 fibers in the same molded connector ferrule. The fiber density of the connector is twice that of a stacked connector.

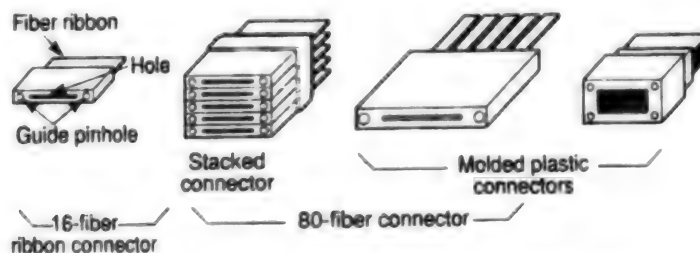


Figure 2. Schematics of Multifiber Connectors

It has been confirmed that the average jointing losses of 16 and 80 multi-fiber connectors are 0.2 and 0.35 dB, respectively. In practice it will be possible to use 80 multi-fiber connectors to join optical fiber cables containing up to 1,000 fibers.

## 2.3 Optical Cable Jointing Technique<sup>(3)</sup>

By using the low-loss and multi-fiber connector described in the previous section, it will become possible to form an all connector optical cable joint. As the time required to form a fusion splice is twice that needed for connector jointing, the latter technique will considerably reduce the total cable jointing time. Moreover, by using 80 fiber connectors, the cross sectional area of the pre-connectorized pulling heads will be greatly reduced, therefore allowing them to pass through a 75mm diameter conduit.

Figure 3 shows current and future optical cable jointing processes. With the current method, 4 or 8

multi-fiber connectors are contained in the cable pulling heads. After cable installation, the pulling heads are removed. Then mechanically constructed closures are arranged to complete the cable joints. The jointing time using the present technique is about six hours for a 1,000 fiber cable. The procedure with the new pre-connectorized optical cable jointing technique is also shown in Fig. 3. Ten stacked 80 multi-fiber connectors are used in the pulling head. A spare length of 16-fiber ribbon is arranged within the cable pulling head. In order to join the cable, stacked multi-fiber connectors are pulled from the pulling head after attaching the lower cover. Then, the optical connector endfaces are cleaned and index matching gel is applied. The closure assembly processes are greatly simplified in this jointing process. Cable jointing times are reduced to one-fifth that for connector jointing using 4 or 8 multi-fiber connectors and one-tenth that for the fusion splicing process. The outer diameter of the 800 fiber pulling head is 71mm. This makes it possible for it to pass through the conduit.

The high density optical cable and cable jointing technologies described in this section will be available early in 1995.

## 3. New Optical Fibers for Long Span Transmission Systems

In this section new optical fibers for long span transmission systems are described. Figure 4 illustrates an optical power level diagram for a long span transmission system. Various approaches have been made in order to increase repeater intervals. These include the enhancement of optical signal power by using optical amplifiers, the reduction of loss in optical fibers, the improvement of minimum detectable power by coherent detection, and the restoration of the signal pulse waveform distorted by chromatic dispersion of the optical fibers.

In this paper, various techniques concerning optical fibers in order to overcome the loss limit for transmission distance will be discussed in detail.

### 3.1 Imperfection Loss Reduction by Viscosity Matching

Among various loss factors of optical fibers, absorption losses originated from transition metal ions and hydroxyl radicals have been reduced to negligibly small,

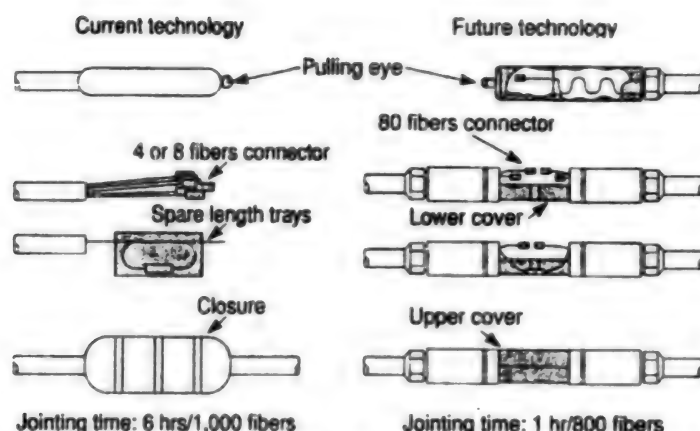


Figure 3. Optical Cable Pulling Heads Containing Spare Length

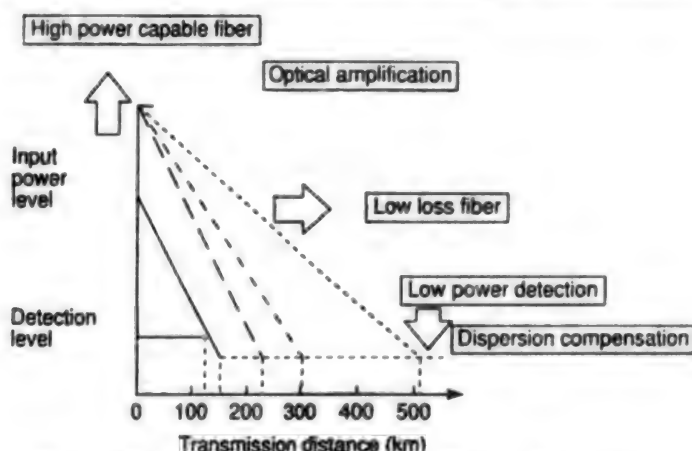


Figure 4. Techniques for Transmission Distance Expansion

owing to untiring efforts in fabrication techniques. As a result, Rayleigh scattering and infrared absorption losses intrinsic to the glass materials and structural imperfection loss which may be induced during fiber drawing process are dominant loss factors in the practical silica based optical fibers.

Thus, in order to realize a low loss optical fiber, care must be taken to reduce the residual stress which is induced during the manufacturing process and which depends on the magnitude of the viscosity difference between the core and cladding and on the fiber drawing tension.<sup>(4)</sup>

The residual stress would be drastically reduced if the viscosity of the core and cladding materials were the same.<sup>(5)</sup>

A method for designing an optical fiber with a homogeneously viscous cross section is reported for an arbitrary refractive index profile by utilizing two kinds of dopant which have different effects on the viscosity of the host fiber material.<sup>(6)</sup> The loss reduction effect by matching the viscosity between the core and the cladding was confirmed experimentally.<sup>(7)</sup> Viscosity characteristics of silica glasses

doped with F,<sup>(8)</sup> GeO<sub>2</sub>,<sup>(9)</sup> and codoped with F and GeO<sub>2</sub>,<sup>(10)</sup> which are necessary to design the viscosity-matched optical fibers, have also been reported.

The viscosity matching technique will be very effective for imperfection loss reduction in dispersion shifted fibers<sup>(9)</sup> and dispersion compensation fibers<sup>(11)</sup> whose viscosity differences between the core and cladding are very large due to large dopant concentration difference between the core and cladding compared to those in standard single-mode fibers.

### 3.2 Input Power Enhancement by Suppression of Stimulated Brillouin Scattering

#### 3.2.1 Background

Owing to a recent remarkable development in optical amplification technique,<sup>(12)</sup> optical transmission systems utilizing high power light sources with more than 20 dBm have become realistic. However, the proportionality between the input and output power from a long optical fiber is violated when the input power exceeds a threshold power of about 5 mW (7dBm) for conventional fibers<sup>(13)</sup> as shown by the

open circles in Fig. 5. Thus, the output power from the optical fiber is limited to a constant value however intensive the launched power into the fiber is. This phenomenon is governed by interaction between light waves and acoustic waves in the optical fiber and is called the stimulated Brillouin scattering (SBS).

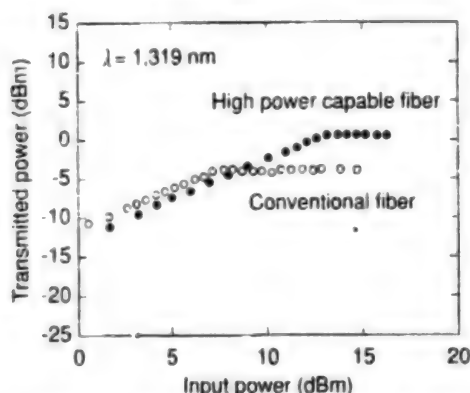


Figure 5. Transmitted Powers as a Function of Launched Power. Open Circles: Conventional Fiber. Filled Circles: High Power Capable Fiber with Nonuniform Dopant Concentration

This phenomenon can be suppressed by broadening the optical frequency spectrum of the input light or the scattered light by acoustic waves. The former is effectively realized by adopting the signal modulation methods such as the phase modulation<sup>(14)</sup> and frequency modulation.<sup>(15)</sup> In the latter case, the stimulated Brillouin scattering will be suppressed when the Brillouin frequency shift is nonuniform along the fiber. That is, the co-operation of the scattered light is reduced by broadening the spectrum of the scattered light even if the spectral width of the input light is very narrow as in the case of the intensity modulation systems.

In this section, various techniques for high power capable fibers are described in which the stimulated Brillouin scattering is suppressed without regard to the signal modulation method.

### 3.2.2 Optical Fibers With Nonuniform Strain Distribution

The Brillouin frequency shift changes linearly with the strain applied to the optical fiber.<sup>(16)</sup> By utilizing this characteristic, two attempts have so far been made in order to suppress the stimulated Brillouin scattering.

In one attempt,<sup>(17)</sup> a periodic strain was induced in a fiber with a pure silica core and fluorine doped cladding by varying the fiber drawing tension, which doubled the effective input power compared to conventional single-mode fibers.

In the other attempt<sup>(18)</sup> the stimulated Brillouin scattering was suppressed through the use of a cabling process. Residual sinusoidal stress was induced in fibers by stranding them into a cable with a double helix structure. The effective input power was raised by 7 dB compared to that for conventional fibers.

With both techniques, nonuniform strain broaden the Brillouin gain bandwidth and suppresses the stimulated Brillouin scattering.

On the other hand, large residual stress is undesirable with respect to the long term reliability of optical fibers because it increases the probability of fiber breakage due to fatigue.<sup>(19)</sup> Thus, high strength fiber such as carbon coated fibers should be used to ensure the long term reliability when inhomogeneous strain is introduced.

### 3.3 Optical Fibers With Nonuniform Dopant Distribution

The stimulated Brillouin scattering can be suppressed in strain free single-mode fibers by utilizing the dopant concentration dependence of Brillouin frequency shift.<sup>(20)</sup>

An optical fiber for SBS suppression was fabricated as follows.<sup>(21)</sup> First, a soot preform with a GeO<sub>2</sub> doped silica core and pure silica cladding was made by the VAD method. It was then consolidated into a glass preform in a fluorine atmosphere. The fluorine concentration was controlled so that it gradually increased along the length of the preform. Finally, the glass preform was jacketed with a fluorine doped silica glass pipe.

The dotted, solid and broken lines in Fig. 6<sup>(21)</sup> show the refractive index profiles of the jacketed preform at its two ends and near the center, respectively. As shown in Fig. 6,<sup>(21)</sup> the refractive indices of the core and the inner cladding change gradually by an amount of 0.2 percent, while the refractive index difference between them remains constant.

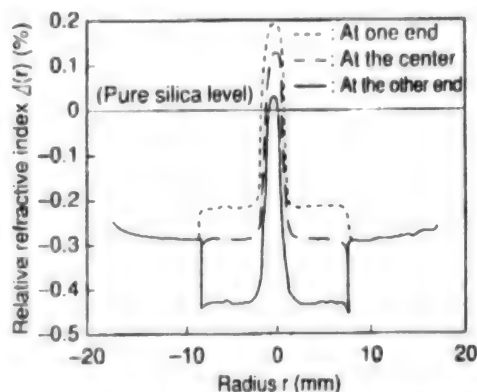


Figure 6. Refractive Index Profiles of the Jacketed Preform for SBS Suppression Fiber with Inhomogeneous Dopant Concentration

The optical loss of a 29 km long single-mode fiber drawn from the preform was 0.23 and 0.43 dB/km at the wavelengths of 1.55 and 1.3 μm respectively. The mode field diameter at both its ends was about 10 μm at a wavelength of 1.55 μm.

The input and transmitted light powers from the test fiber at a wavelength of 1.32 μm are shown by the filled circles in Fig. 5. Nonlinear phenomenon is observed when the launched power exceeds 13 dBm, which is about 6 dB larger than the value of 7 dBm for conventional fiber. In the same manner,



7 dB SBS suppression is confirmed experimentally at a wavelength of 1.55  $\mu\text{m}$  in the test fiber. The nonuniformly doped SBS suppression fiber is advantageous from the viewpoint of long term reliability because it is essentially strain free.

#### 4. Towards the Future

It has been 10 years since optical fiber cables were introduced into long haul trunk transmission systems. It is considered that optical fiber cable will become widely used in subscriber networks once its performance has been improved and once its disadvantages compared to metallic cable have been overcome. Key technologies are the achievement of ultimate lightness and the smallest possible cross section for the optical fiber cables and simple cable jointing techniques.

Techniques for long span transmission systems have been steadily developed such as the imperfection loss reduction by viscosity matching and the high power capable fibers which bring the high signal light power effectively to the receiver.

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## Optical Soliton Communication Technologies for High-Speed Networks

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[Article by Masataka Nakazawa]

[Text] *Current progress on high-speed soliton communication technologies is summarized, in which the use of erbium-doped fiber amplifiers has been a major breakthrough for the soliton communication. Prospects for soliton communication are described with a view to a future all-optical network.*

### Introduction

The word "soliton" was first coined by Zabusky and Kruskal in their paper which deals with the wave motion of a one-dimensional nonlinear lattice vibration known as the Korteweg de Vries (KdV) equation.<sup>(1)</sup> They found that the shape of the nonlinear wave remained unchanged even after solitary waves had collided with each other, and that it behaved like a particle. Therefore they coined the word "soliton" by combining "solitary" with the suffix "on" which is commonly used for describing particles as with photon or electron. In 1971, Zakharov and Shabat showed analytically that a soliton can also be generated in a nonlinear dispersive medium. In this case, the nonlinearity is self phase modulation (SPM), and the dispersion is group velocity dispersion (GVD). These two counteracting effects create solitons which can be described by the nonlinear Schrodinger equation (NLS).

In 1973, Hasegawa and Tappert proposed the possibility of forming an NLS soliton in optical fibers which are used for optical communications.<sup>(2)</sup> It had been a long time to demonstrate that such a nonlinear pulse exists in a conventional single-mode fiber. In 1980, Mollenauer et al. showed experimentally that optical solitons described by the NLS really existed in a single-mode optical fiber with the use of a color center laser which emitted a picosecond optical pulse train at 1.5  $\mu\text{m}$ .<sup>(3)</sup>

An ideal optical soliton can propagate without distortion over long distances. However, in practice, fiber loss, which is inevitably caused by Rayleigh scattering, eventually destroys the soliton, and therefore it is important to compensate for the loss to retain the superbly consistent nature of the soliton. Recently most of the difficult problems which had prevented the realization of soliton communication have been solved by using erbium-doped optical fiber amplifiers (EDFAs).<sup>(4)</sup> This paper describes how optical soliton communication has been established together with the recently developed "soliton control" technique.<sup>(5)</sup>

### 1. Prospects for Optical Soliton Communication

An optical soliton pulse does not change its waveform as it propagates in the fiber because SPM compensates for the pulse broadening. The temporal broadening due to

the absolute value of GVD can be compensated for by the compression due to SPM with negative GVD, making a stable optical pulse. This is an optical soliton. In a silica optical fiber, negative GVD (anomalous dispersion) exists in the wavelength region longer than 1.3  $\mu\text{m}$ . Hence, optical solitons are created in the loss minimum region of silica fiber at around 1.5  $\mu\text{m}$ .

Figure 1 summarizes methods for realizing large capacity, long distance optical communications, in which they can be categorized as time domain and frequency domain approaches. In the time domain approach, we have ordinary high speed communication near zero dispersion and optical soliton communication. In both cases, the dispersion compensation is essential in order to prevent the signal pulses from broadening. For a conventional linear system, a linear dispersion compensation technique is used, and for a soliton system the dispersion is nonlinearly compensated by SPM. In the frequency domain, we have WDM (Wavelength Division Multiplexing) coherent communication. As solitons with short widths are high power pulses, they are useful not only for high speed communication but also for optical signal processing and optical material evaluation.

The prospects for optical soliton communication are as follows.

- (1) Solitons can be generated in the loss minimum region.
- (2) Short pulse transmission is possible over long distances, which enables ultrahigh speed communication.
- (3) There is no waveform distortion over long distances. This is useful for long distance communication.
- (4) Lastly they are dispersion free, which means there is no need to set the pulse wavelength exactly to zero dispersion.

Figure 2 shows that the regions in which the soliton pulse is applicable to optical communication. The line on the left hand side represents an ordinary IM/DD (intensity modulation/direct detection) optical system and that on the right represents soliton transmission. As seen, for a low bit-rate of less than 10 Gb/s over a few thousand kms, conventional IM/DD systems are superior to soliton communication and therefore, there is no need to use solitons. There have been many promising results reported for long distance NRZ signal transmissions at 10 Gb/s.<sup>(6)</sup> In high bit-rate systems of greater than 20 Gb/s or so, the optical soliton system is superior to conventional IM/DD. However, even in soliton transmission, the maximum transmission distance is limited by the coherent interaction with the amplifier noise, which is called the Gordon-Haus limit.<sup>(7)</sup>

### 2. Amplification of Optical Solitons

It is important to compensate for the fiber loss with optical amplifiers in order to maintain the soliton energy over long distances. In Fig. 3, we show two methods for transmitting

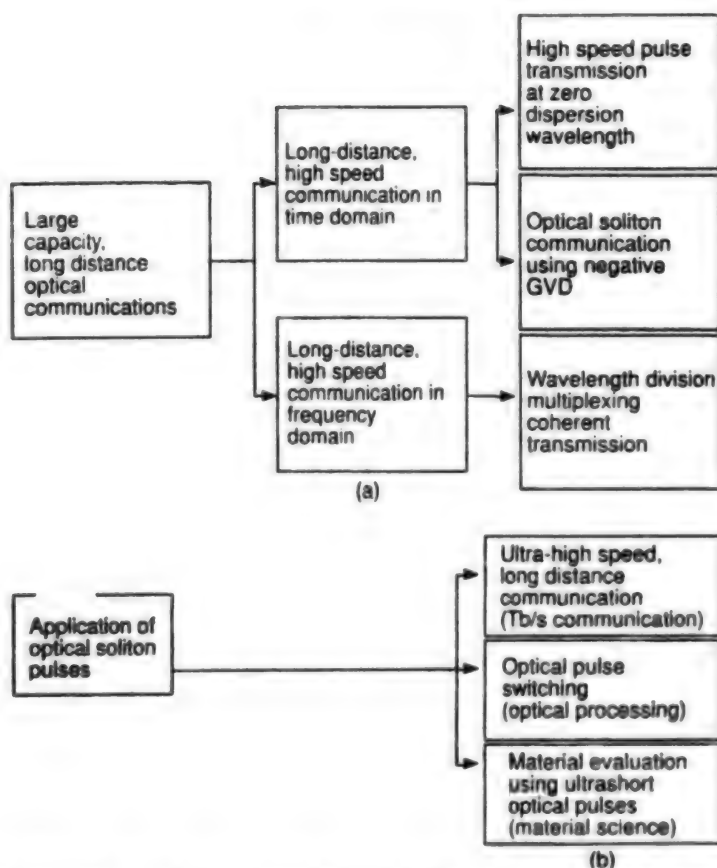


Figure 1. Position of Soliton Communication in High-Speed, Long-Distance Optical Communication and Its Applications

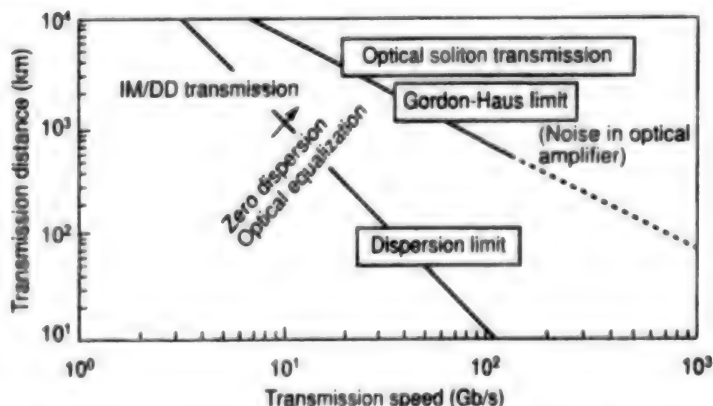


Figure 2. Comparison of Transmission Distance vs. Transmission Speed for Conventional IM/DD and Soliton Transmissions

solitons over long distances. (A) is the distributed optical amplifier method, in which Raman amplification or distributed erbium-doped fiber is used. However, the gain coefficient of SRS in silica-based optical fiber is rather small, which means that high-power lasers are required as pumping sources to generate SRS in optical fiber. In addition, the SRS amplifier is noisy.

In order to overcome these difficulties, a new soliton transmission method suitable for a lumped amplifier system was proposed as shown in (B) of Fig. 3.<sup>(8)</sup> This method was realized by using EDFAs and its stability has been experimentally and theoretically proved, resulting in a major method for soliton communication.<sup>(9)</sup> It is important to note that this technique has a wide range of

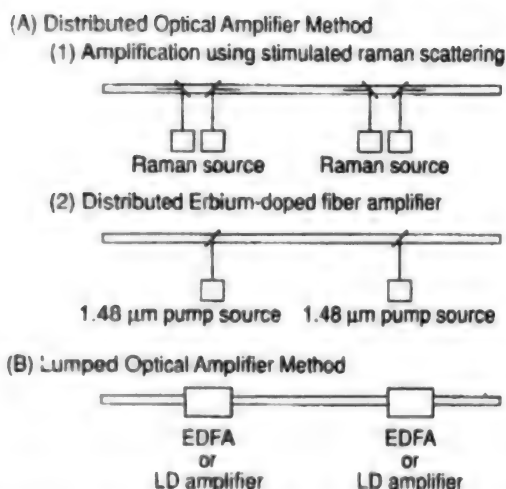


Figure 3. Optical Amplification Methods for Soliton Transmission Over Long Distances

applicability under the condition that the repeater spacing is shorter than or comparable to the soliton period, depending on the maximum required transmission distance.

When a normal fiber is used, the soliton power is about 1 W, which is not very easy to generate from a laser diode. However, when a dispersion-shifted fiber is used, for example a soliton pulse width of 20 ps, the soliton peak power is as low as a few mW. These low peak powers enable us to construct actual soliton transmission systems with the use of EDFAs.<sup>(6)</sup>

### 3. Ultrahigh-Speed Soliton Transmission Experiments

Recently, soliton transmission technology has matured considerably through the use of EDFAs. In order to show

that soliton transmission has several advantages over conventional IM/DD or coherent systems, it is now very important to undertake single-pass long-distance high-speed data transmission experiments with pseudo-random data signals, as has already been demonstrated in high-speed linear systems with NRZ signals.<sup>(6)</sup> In response to this need, many soliton experiments have been reported.<sup>(10)</sup> Here we describe single-pass soliton data transmission experiments of 20 Gb/s over 2,000 km and 40 Gb/s over 1,000 km.

The experimental setup for the soliton data transmission is shown in Fig. 4. The soliton pulse width was 12 ps. The pulse was modulated at 10 Gb/s with a  $2^{23}-1$  pseudo-random binary sequence (PRBS) using a high speed  $\text{LiNbO}_3$  intensity modulator. To obtain 20 Gb/s pulses, an optical multiplexing technique was used with two 3 dB fiber couplers. For the 40 Gb/s transmission experiment, a polarization multiplexing technique was used which enabled the bit rate to be doubled (20 Gb/s  $\times$  2). The soliton transmission fibers (STFs) were dispersion-shifted fibers with an average group velocity dispersion of  $-0.4$  ps/km/nm at  $1.552$   $\mu\text{m}$ . The average soliton period was 189 km.

The coded pulses were amplified by EDFAs to an average soliton power level of approximately +1 dBm. The average  $N = 1$  soliton peak power was 4 mW. The EDFA repeater spacing was 50 km and the average fiber loss including the connector loss for one span, was about 11.5 dB. Each EDFA consisted of a  $1.48$   $\mu\text{m}$  InGaAsP LD for pumping, a WDM coupler, a polarization-insensitive isolator, erbium fiber, and a 3 nm optical filter. After propagation over 2,000 km, the output soliton was optically demultiplexed to a 10 Gb/s signal by using  $\text{LiNbO}_3$  intensity modulators and a clock extraction circuit. The 40 Gb/s signal was demultiplexed with a polarization beam splitter to two 20 Gb/s signals.

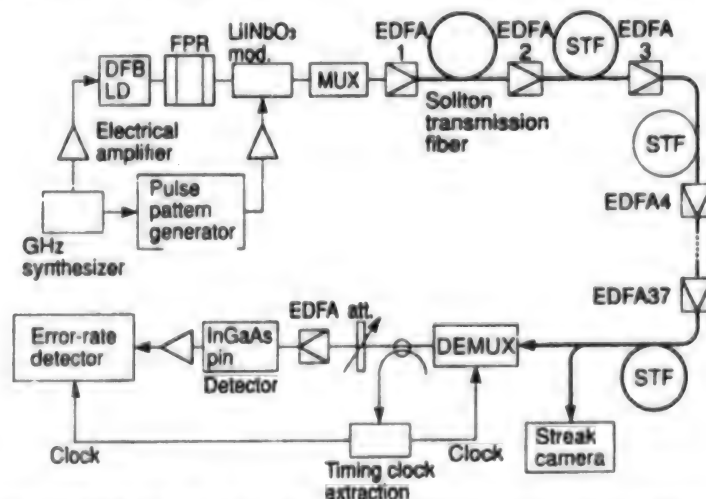


Figure 4. Experimental Setup for 20 and 40 Gb/s Soliton Data Transmissions Using EDFAs. A 40 Gb/s Signal Was Generated by a Polarization Multiplexing Technique

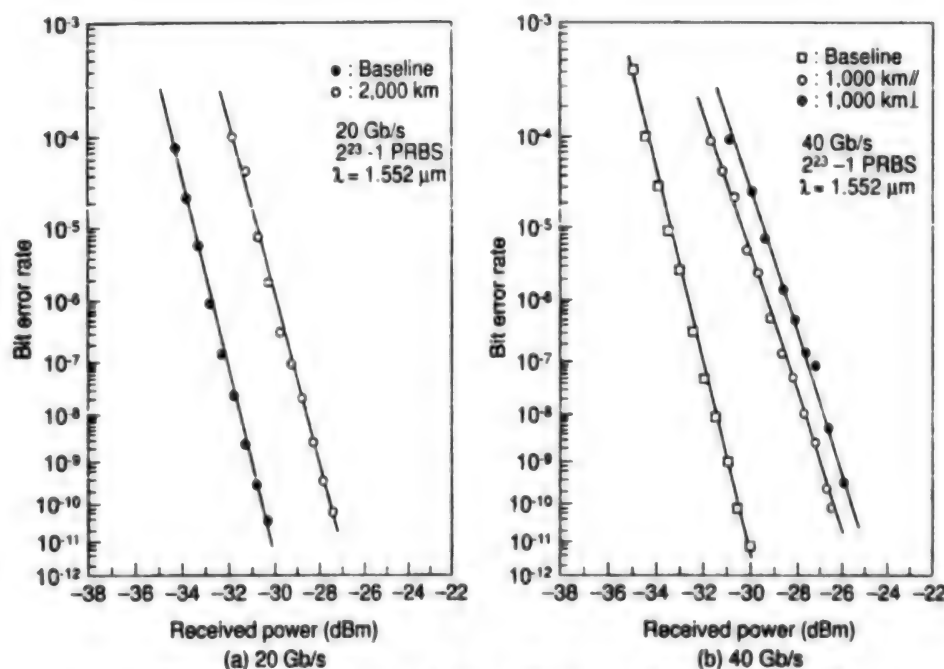


Figure 5. Bit Error Rates at 20 and 40 Gbs vs. Received Optical Power

The 10 Gb/s signals were then detected with a high speed InGaAs PIN photodiode and the bit error rate (BER) was measured.

Figure 5 (a) shows the BER characteristics measured before and after the 2,000 km transmission at 20 Gb/s. Although there was a power penalty of 3 dB, there was no indication of the existence of an error floor. This penalty is the result of the Gordon-Haus jitter under a slight soliton-soliton interaction. The BER was less than  $1 \times 10^{-10}$  after the transmission. Figure 5 (b) shows the BER characteristics before and after the 1,000 km at 40 Gb/s. There was also no error and a BER of below  $10^{-10}$  was obtained for both polarized outputs. The bit rate and transmission distance product of 40Tb/s x km obtained in these experiments are the highest values in a straight-line soliton data transmission experiment reported to date.

#### 4. Soliton Control Towards High Speed All Optical Network and Future Prospects

A new technology has recently been proposed to overcome the Gordon-Haus limit, ASE accumulation, and soliton-soliton interaction.<sup>(5)(11)</sup> This technique is called "soliton control" and was used to achieve a one million km soliton transmission in 1991. Synchronous modulation (soliton control in the time domain) enables us to retime the position of the soliton pulse which experiences jitter as a result of amplified spontaneous emission (ASE) noise. It is also possible to remove the interaction forces which inevitably occur between closely adjacent solitons. A bandpass filter with a 0.3 - 0.4 nm bandwidth was also installed in the loop to stabilize the soliton energy as a soliton control in the frequency domain.<sup>(5)(11)</sup>

Recently, we have shown that the bit-error-rates for a PRBS soliton signal at 10 Gb/s exhibit no degradation whatsoever after transmission over 1 million km. The experimental setup for the new soliton transmission scheme with soliton control is shown in Fig. 6. The fiber loop was up to 500 km long and an EDFA was installed every 50 km. Soliton controls in the time and frequency domains play an important role in enabling us to maintain a repeater spacing of as much as 50 km with 24 - 30 ps solitons. In the present scheme a timing clock extraction circuit is newly installed in the loop to replace the clock signal at the transmitter and the synchronous modulator is driven by the extracted sinusoidal signal. With the present technique, the clock signal is automatically extracted from the transmitted signal and, therefore, there is no need to use a variable delay. This means that the transmitted solitons control themselves over any distance.

Fixed data patterns at 10 Gb/s transmitted over 50 million km (250 sec.) and 180 million km (15 min.) are shown in Fig. 7 (a) and (b), respectively. The data patterns in (a) and (b) are <0100111001> and <1100110011>, respectively. It is important to note that the accumulation of ASE and non-soliton components at "0" signal is negligible.

The bit-error-rate (BER) under soliton control is important in order to determine whether or not the present soliton control technique can really preserve data without deterioration. Results of BER measurements at 10 Gb/s are shown in Fig. 8, where a  $2^9-1$  PRBS was used. The triangles, closed circles, and open circles



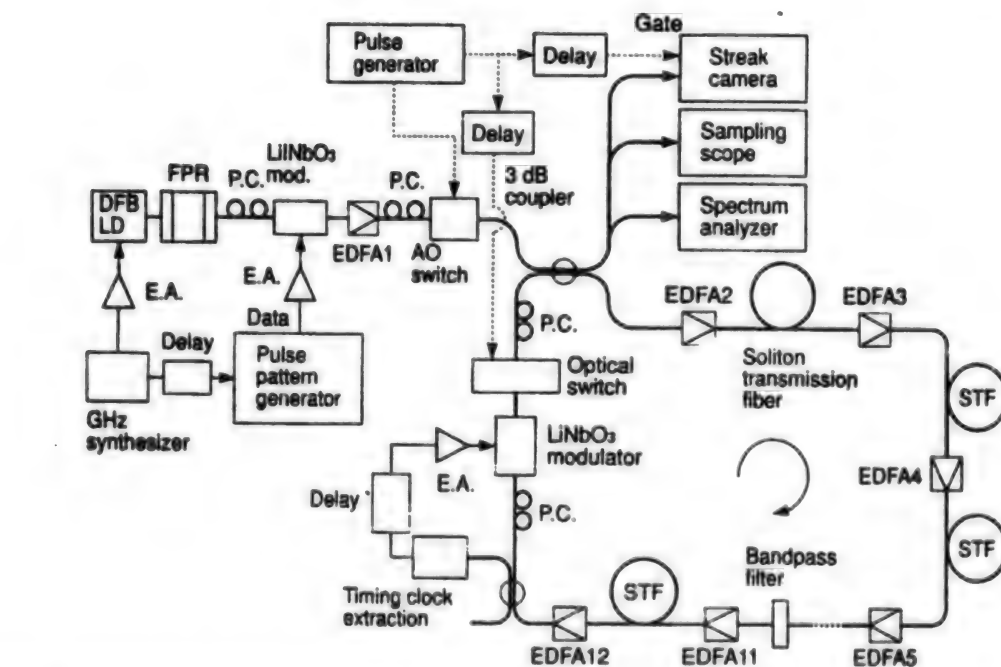


Figure 6. Experimental Setup for Soliton Data Transmission Over Unlimited Distances With Soliton Transmission Controls in the Time and Frequency Domains

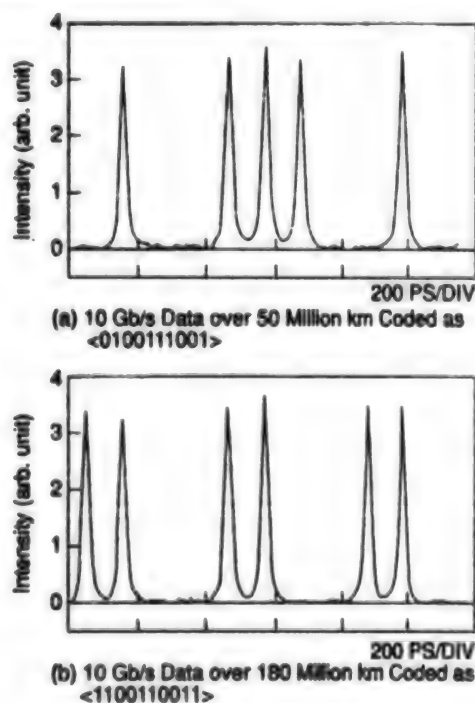


Figure 7. Transmitted Data Patterns at 10 Gb/s Over 50-180 Million kms

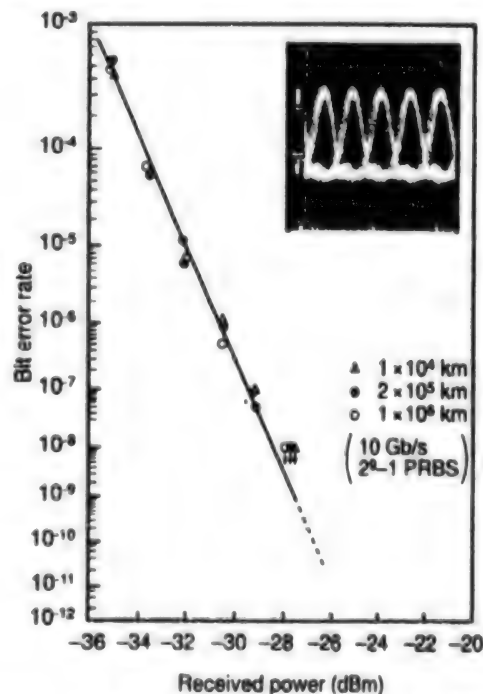


Figure 8. Bit Error Rate Measurements of the Soliton Data Signal at 10 Gb/s Transmitted Over One Million km. The Inset Photo is an Eye Pattern Corresponding to One Million km.

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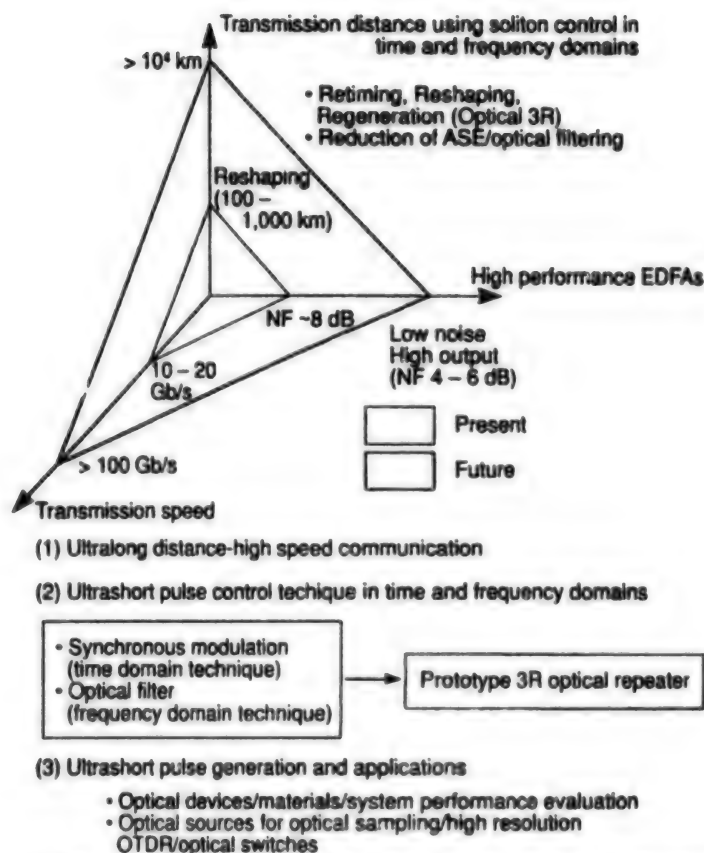


Figure 9. Future Prospects for Soliton Transmission Technology

correspond to BERs at  $1 \times 10^4$  km,  $2 \times 10^5$  km, and  $1 \times 10^6$  km, respectively. As can be clearly seen, these BERs are almost the same, which means that there was no degradation at all in the data signal after transmission over one million km. The inset photo shows an eye pattern after a one million km transmission. The eye is clearly open and suggests that Gordon-Haus jitter has been eliminated. It is therefore concluded that error free transmission over unlimited distances is possible with this technique.

Finally, the future prospects for soliton technology are presented in Fig. 9. The transmission distance under soliton control in the time and frequency domains, transmission speed, and EDFA performance are adopted as the three axes. The present situation is shown by the hatched area. Our goal is to extend the three points to the values shown in the figure. For example, a transmission speed exceeding 100 Gb/s, a transmission distance of longer than 10,000 kms, and the development of a low noise high power EDFA are very important if we are to construct an all optical high speed network.

As these technologies reach maturity, we will have the following future prospects. Firstly, ultralong distance high speed communication will certainly be realized with solitons. Secondly, an ultrashort pulse control technique will

be established. Thirdly, the generation of ultrashort pulses will become much easier and the application of this technology will have resulted in considerable progress being made in high speed optical communication.

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### Wireless PBX System Based on Personal Handy Phone Concept

43070116A Tokyo NEC RESEARCH & DEVELOPMENT  
in English Apr 94 pp 196-203

[Article by Kiyokazu Otsuka, Jun Moriyama, Shigeo Fujii, Masatsugu Nakagawa, and Akira Yorita of the Business Communications Division, Osamu Noda of NEC Communication Systems, Ltd. and Kazuhisa Fujita of NEC Engineering, Ltd.]

[Text]

**Abstract:** A Personal Handy Phone (PHP) system is under development in Japan, which is a telephone communication system utilizing digital cordless telephone sets as common terminals in offices, homes and outdoors. Public service of the PHP is estimated to start within a couple of years. In advance of this public service, a wireless PBX which is a business-oriented telephone communication system will be placed on the market in 1994. This wireless PBX system employs a 1.9 GHz bandwidth and compressed digital transmission rate to increase the number of radio channels. It is also designed for the effective utilization of frequencies by limiting the transmission power to less than 10 mW, thus reducing the size of the radio zone (cell). It also employs a software configuration adaptable to the IN (Intelligent Network), targeting for growth into a next-generation system, especially for a flexible evolution to Universal Personal Telecommunications (UPT) and multimedia communications. For the purpose of improving software portability and expandability, the wireless PBX system is provided with software of a layered structure and a procedure to control the terminals by logical identifiers in addition to a virtual hardware technique. Further, by introducing the IN's Basic Call State Model (BCSM), both the terminal mobility and service descriptive characteristics have successfully become compatible. This paper describes the target, configuration and functional implementation of the wireless PBX mentioned above.

### 1. Introduction

A variety of mobile communications systems, including portable telephones, mobile telephones, radio pagers, cellular telephones, etc. are rapidly gaining popularity. In these conditions, a Personal Handy Phone (PHP), which is a mobile communications system using digital cordless telephone sets as common terminals in offices, homes and outdoors, is under development.

As the future global integration of radio systems of diversifying mobile communications such as portable telephones, mobile telephones, PHP, etc., an FPLMTS (Future Public Land Mobile Telecommunications System) is being studied by the ITU. The UPT (Universal Personal Telecommunications) also realizes such sophisticated services as, for instance, location-free call termination for individual users by use of an assigned personal number.

Based on the aforementioned future mobile communications system and with the target set for evolution to UPT in the future, a wireless PBX system is developed implementing IN (Intelligent Network) architecture.

## 2. Mobile Communications

The current portable telephone is an analog system using frequencies in the 800 Hz band range. It is estimated that the availability of applicable frequencies will reach its limit within several years. Although the utilization of an adjacent microwave band range (from 1 GHz to 3 GHz) is being studied because of this situation, the shortage of frequencies is a major problem to overcome in the promotion of personal mobile communications.

To solve this problem, two key technologies, digitization and micro-cell technology, are being introduced.

### (1) Digitization

A digital radio system allows one radio carrier to be shared by plural time slots. Also, as a digital system is capable of controlling call processing while a call is in progress, it may be able to provide a more sophisticated system, such as a multifunction wireless telephone system.

Further, such user-friendly services as hands off, roaming, etc. which are very useful while users are moving from one place to another, can be controlled more easily.

Since a digital radio system can handle digital data directly, it is also easy to implement evolving future multimedia communications.

### (2) Micro-Cell Technology

Demands for mobile communications systems are rapidly increasing of late, along with the introduction of a portable telephone system. When a private network is considered, it is usually used in a highly populated environment, such as in an office building, micro-cell technology makes the radio zone (cell) to be covered by one base station smaller and enables many base stations to be installed in the area. It thus enables many users to utilize the digital telephone system services.

From the above analysis, it can be expected that mobile communications systems in offices will be digitized and the application of micro-cell technology may be accelerated.

Besides the above two key technologies, there are two other techniques that are oriented toward a future UPT, one is the personalization of communications, and the other is intelligent communications services.

### (3) Personalization

The ultimate target of mobile communications is to allow a user to communicate with any desired party anywhere at any time. As a means to achieve the personalization of these communications, a UPT is under consideration.

For the UPT, each user is assigned a personal number, and the network manages a personal profile on the database according to the personal number. This personal profile management allows users to utilize a variety of personal services, such as screening, etc., by referencing the personal profile from any location.

### (4) Intelligent Communications Services

As represented by NEC's OAI (Open Application Interface), the current PBX provides such sophisticated telephone services as roaming services, a directory assistance service, etc., through interfacing with a computer system. Also, PC (Personal Computer) telephony, which incorporates telephone functions in a PC, will be placed on the market in 1994. It provides various telephone services like scheduled call origination through the PC software.

As a result of the fusion between telecommunications and computers, communications services are steadily becoming sophisticated.

## 3. Personal Handy Phone (PHP)

Commencement of PHP public services are estimated within a couple of years. PHP is a digital mobile communications system with an expanded operational range, where Personal Station (PS) can be used not only indoors but also outdoors.

By installing many base stations outdoors with the same functions as a master base station operating in homes or offices, the PHP allows a user to use mobile communications services through one PS, regardless of whether the user is indoors or outdoors.

The estimated subscription rate for the PHP and the basic monthly fixed rate will be less than the current portable telephone cost. Note, however, that the PHP cannot cope with high-speed user movements, and its outdoor service areas will be limited to major cities for the time being.

On the other hand, the introduction of PHP within offices is expected to start gradually from 1994. Since the PHP is a digital cordless telephone system, it features various merits, such as less noise regardless of the strength of the radio wave, improved privacy protection and long battery power compared with the present analog cordless telephone.

In the future, the PHP can evolve so that facsimiles and PCs can be connected to a public network. In addition, the same terminal can be used indoors and outdoors; thus, when a PBX receives a call addressed to a sales clerk who is out of the office, the PHP can automatically transfer the call from the PBX to the addressed sales clerk's PS.



#### 4. Development Concept

The wireless PBX employs an architecture permitting the construction of a system that best fits user needs by selecting and combining required functional modules.

The system can be constructed to a desired size by combining small-sized modules that can be operational as stand-alones. Also, by combining and adding multiple modules with specific functions, a multifunctional system can be constructed.

This wireless PBX provides a system architecture by combining PBX Modules (PBXMs) equipped with conventional PBX functions and Wireless Modules (WLMs) equipped with wireless functions. This system architecture can be flexibly adapted to installations ranging from a small-sized building to a large factory by changing the number of modules combined. Since the WLM can be installed remotely from the PBXM, physically scattered locations and/or a relatively large site can be covered as a service area.

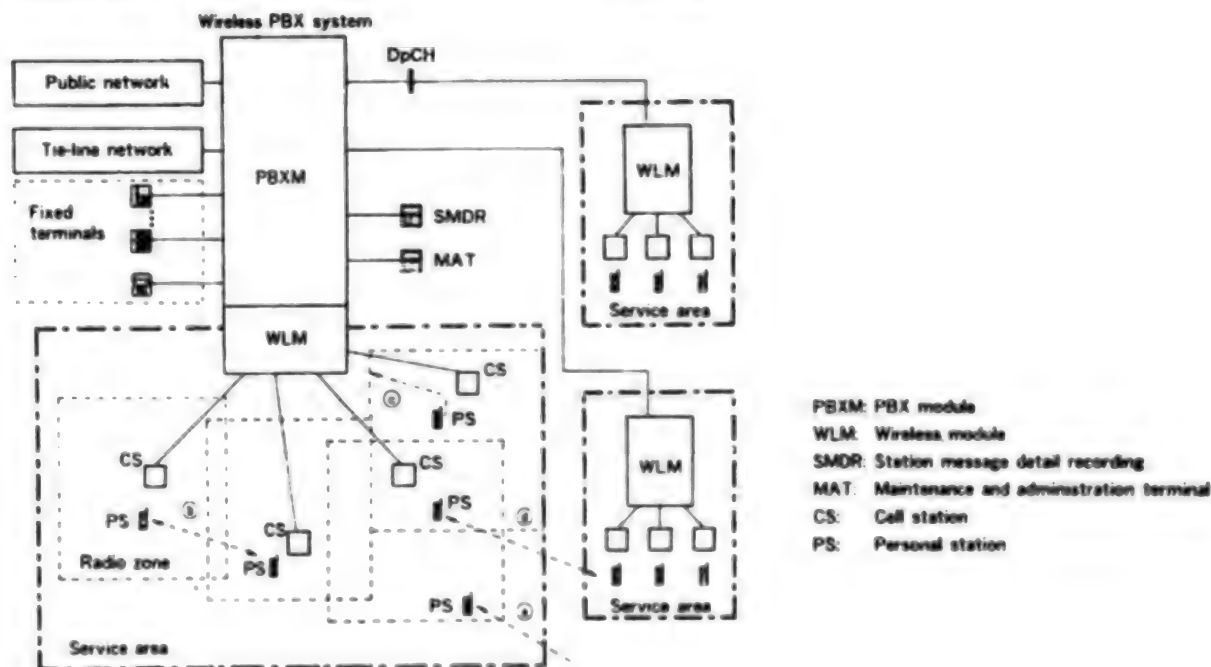
Further, the use of a remote maintenance terminal facilitates maintenance and administration of the system by centralizing management for plural modules installed in various locations.

#### 5. System Configuration

##### 5.1 System Configuration

Figure 1 shows the network configuration of the wireless PBX system.

The WLMs can be installed either adjacent to the PBXMs or remotely from the PBXMs. The WLMs to be connected to the PBXMs can be decentralized throughout a wide area, expanding the service area to be served. The system accommodates an associated public network, tie-line network and fixed terminals into the PBXMs and accommodates each Cell Station (CS), which is a base station for the WLMs to form a radio service area. The user of each PS can communicate from any location in the service area under the control of the WLMs.



- ① PS authorization: In order to prevent system access by unauthorized telephones, the WLM identifies if the calling telephone sets are pre-authorized. If the WLM identifies the telephone as being unauthorized, the system prevents the telephone from originating a call.
- ② Hands off: When a communicating party moves between radio zones within the service area, the system automatically hands off the call to the next radio zone and thus the communicating party can continue the call while moving within the service area.
- ③ Location registration: If a PS has moved to the service area of another CS, it automatically registers the location of the current area. Calls are terminated to the area for which location has been registered.
- ④ PBX roaming: Even if PS users move to another WLM system's service area, they can originate/receive a call.

Figure 1. Wireless PBX Network Configuration

By connecting a SMDR (Station Message Detail Recording) to the PBXMs, call-accounting information can be collected on either an individual or a group basis, regardless of whether the call originated from a PS or a fixed terminal. Also, both the PBXMs and the WLMs can be managed on a centralized basis through one Maintenance and Administration Terminal (MAT) set.

In this study, the PBXMs mean NEC's APEX7400 series. However, this paper excludes information directly concerning the APEX7400, and mainly describes those portions pertaining to the integration between the PBXMs and the WLMs, and to the WLMs themselves.

## 5.2 Hardware Configuration

The hardware of the wireless PBX consists of a CS, PS, PBXM and WLM.

### (1) Features of the CS and PS

Table 1 below shows the performance characteristics of the CS and PS of the wireless PBX.

Table 1. Features of the CS and PS

Items	Performance characteristics
Radio frequency	1.9 GHz band
Channel spacing	300 kHz
Access method	TDMA (Time division multiplex access)
Transmission method	TDD (Time division duplex)
Multiplexing	4 multiplexing
Communicating method	Duplex operation
Modulation	4-value phase modulation ( $\pi/4$ shift QPSK)
Modulation signal rate	384 kbps (32 kbps ADPCM for the voice encoding system)
Transmitting power	Less than 10 mW
Transmitting gain	Less than 2.14 dBi

As for the voice-encoding system, a 32 kbps ADPCM (Adaptive Differential PCM) is used, and four speech information channels (32 kbps) and one control signal channel are multiplexed on one radio carrier.

### (2) Features of the PBXM and WLM

The wireless PBX uses APEX7400IMS Model 140 hardware. NEC's 32-bit microprocessor V70 is used as the CPU on the control circuit cards. The exchange switch consists of a one stage time-division switch.

The wireless PBX is interconnected with the CS by an ISDN interface. The WLM and the PBX are interconnected by the primary rate interface of the ISDN. Switching within the WLM is performed by a 64 kbps PCM, and ADPCM is equivalent to PCM conversion is executed at the WLM side.

## 6. Software Configuration

### 6.1 Software Features

Technical improvements of such hardware devices as ATM switches, RISC CPU, etc., are advancing year by year. Besides these improvements, improved techniques for system configurations such as down-sizing, efficiency, etc., are also under way.

However, the software needs to be able to flexibly adapt to such technical improvements through only partial, minor changes. Also, even when terminals/lines have been increased to meet user needs, this situation needs only to be met by adding some functions pertaining to the added portions, instead of rewriting the whole software.

Further, when more sophisticated and complicated services are added to the system, the additions must be made in such a manner that it affects the existing functions as little as possible and promotes the productivity of the added functions.

To achieve these objectives, the software is constructed by applying layering, virtual concept, the separation of calling-party control and called-party control, and the service scenario.

#### (1) Layering

The WLM software is divided into three layers, the OS layer, extended OS layer and call control layer. Also, each functional block is divided into a software module called a Function Block (FB), consisting of a group of functions.

Also, a method equivalent to an interlayer interface is in use as the interface between one FB and another. With the intermodule linking employed in this manner, the independent features and portability of each software module have been greatly improved.

#### (2) Virtual Concept

By employing a virtual concept where the logical identifiers control the hardware by hiding its physical attributes, etc., the software is protected from being affected even if hardware becomes more sophisticated.

Also, the protocols, terminal attributes and line attributes are hidden from the call control by terminating and unifying the lower layers of the various terminals and networks.

#### (3) Separation of Calling-Party Control and Called-Party Control

With the addition of several services, calling- and called-party services affect each other, and the complexity of the software is increasing.

By separating the services to be processed on the calling-party side from those to be processed on the called side, these services have become less dependent. This separation eliminates the necessity for software corresponding to a combination of calling-party and called-party services.

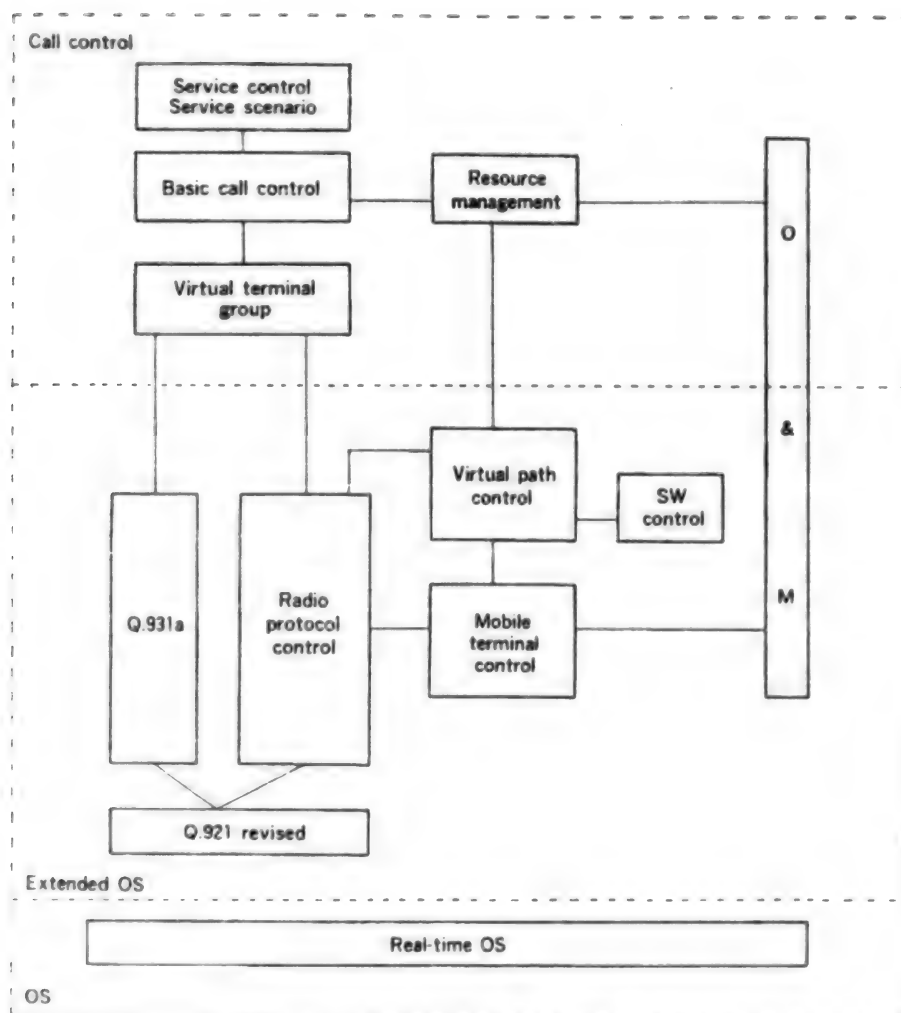


Figure 2. WLM Software Module Configuration

#### (4) Service Scenario

The wireless PBX uses a service scenario methodology provided as the common platform of NEC switching systems. Supplementary services are implemented by programs called service scenarios.

Service scenarios can be designed without knowledge about the protocols and/or terminal attributes, etc. Also, service scenarios can be easily added/removed to/from the system. This service scenario provision helps to reduce mutual dependence among the services. An improvement in the productivity of the new services can thus be expected.

#### 6.2 Software Configuration

Figure 2 shows the software module configuration of the WLM which is divided into call control, extended OS and OS layers.

Typical modules are outlined below.

##### (1) Call Control

###### 1. Basic Call Control

The basic call control executes status transitions according to the BCSM (Basic Call State Model) defined in the AIN (Advanced Intelligent Network), an architecture advocated by Bellcore. And all the services are to be defined on the basis of this BCSM.

###### 2. Service Control, Service Scenario

The service control judges if the conditions required for executing a specific service have all been met and, if the service is executable, it determines how to process it.

The service scenario is a program that actually executes a specific service processing. Plural service scenarios are prepared according to changes in status or events that

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may occur during the execution of the service. The service control, however, selects only one of them, depending on the case involved.

### 3. Virtual Terminal Group

The PBX operation is provided with group services represented by multilines or key operations. The virtual terminal group function, positioned between the basic call control and the protocol, achieves group service.

Through this provision, it is not necessary for the basic call control and/or the service scenario to take care of any of the group services.

### (2) Extended OS

#### 1. Virtual Path Control

A virtual path control has been introduced to avoid competition between path controls from the services and those controls related to the tone/announcement, allowing these services to be designed easily and independently.

Using a specified path-changing pattern from service, the virtual path control independently requests path control and executes an optimum path control with competitive control process.

#### 2. Mobile Terminal Control

The mobile terminal control executes the processing of authorizations, location registrations and hands off. Each process is outlined below.

##### *Authorization:*

When a PS has accessed a WLM, this module performs authorization operations using an encoded key and checks to see if the PS is authorized for access or not.

##### *Location registration:*

Upon receiving a location registration request from a PS, this module memorizes the area in which the PS is located and allows the call to be terminated to the PS according to memorized location information.

##### *Hands off:*

Upon receiving a hands off request from a PS, this module hands the present speech channel over to the speech channel extended to the moving destination.

### (3) Operation & Maintenance (O & M)

Through a traffic measuring function, this module measures the number of calls processed among radio zones and/or the time of blocks encountered respectively on each CS in addition to the number of outgoing and incoming calls.

Also, this module continuously monitors the system equipment for possible failures and stores alarm information. Upon detecting a failure, the module notifies the maintenance personnel by means of a related alarm lamp and the bell.

### (4) MAT

The MAT (Maintenance and Administration Terminal) programs provided on the SIMAP (Smart Installation Maintenance Administration Platform) which is developed to allow the PBX to be set up easily in operational condition, shortens the maintenance time and creates a logical DB of the office data.

The SIMAP uses MicroSoft WINDOWS (WINDOWS is a MicroSoft trademark) as its OS, thus achieving an improvement of the GUI. Also, to promote the efficiency of data installation, the data are set through the use of templates.

## 7. Performance Specifications

### 7.1 System Specifications

Table 2 shows the system specifications of the WLM.

Table 2. WLM Performance Specifications

Category	Item	Contents
System capacity	Total number of valid ch/CS	576ch (3ch x 192CS)
	Number of CS/WLM	192CS (phantom power supply)
	Number of PS/WLM	500 terminals
	Number of terminals for simultaneous connections	Non block
Ambient conditions	Ambient temperature	0 - 40°C
	Relative humidity	15 - 90%
Operating power		-48 V +/- 5 V
Equipment frame dimensions		600(W) x 550(D) x 1,910(H)mm
Maintenance terminal		PC-9800 series



## 7.2 Service Features

Table 3 shows the typical service features of the wireless PBX.

**Table 3. Typical Service Features of Wireless PBX**

Service Name	Outline of Service Feature
Speech Scrambler	By encoding the voice data to be transmitted, the privacy of the call can be secured.
Call Transfer	A PS user engaging in a call depresses the TRANSFER key and dials the number for the desired transfer destination. The original party connected to that PS is then connected to the transfer destination.
PS to PS direct connection	Wherever the called PS is within the service area, the call can be terminated to the PS.
Group Conference	Pre-grouped plural PSs can be called simultaneously.
Out-Of-Cell Announcement	In the case of individual PS call termination, if the call has not been terminated to the called PS because the operating power is off at the called PS or because the called PS is outside the service area, an announcement of "Out-Of-Cell" is returned to the calling party.
Call Forwarding Do not Answer	When the called PS does not answer the call within a predetermined timing, the call can be transferred to a destination which is registered.
Call Waiting-Terminate	When a called PS is engaging in another call, a tone is sent to the called station, notifying the incoming call. The station user may then hold the original call through a key operation and can answer the incoming call.

## 8. Conclusion

This paper has explained the wireless PBX. At present, it is a voice-transmitting telecommunications system within an office. In the near future, interworking with public PHP networks and roaming with the networks will be implemented. To expand the services of the wireless PBX from the initial stage of its introduction, the interworking capability is a major theme to achieve in the future.

On the other hand, topics about multimedia communications are attracting extensive attention, together with those about information infrastructures. Therefore, the provision of mobility in telecommunications must continue to support the initial services oriented to voice transmission and all kinds of information services and advanced data-compression technique.

Based on the above analysis, authors would like to continue their study to achieve the improvement of the present system into a more sophisticated one capable of implementing personal mobility inclusive of a variety of services.

## Acknowledgments

The authors wish to thank all those concerned for their advice and helpful suggestions in the development of this wireless PBX system.

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## Card Type Radio Modem for Portable Information Processing Terminals

43070118A Tokyo NEW TECHNOLOGY JAPAN  
in English Jul 94 p 24

[Text] Japan City Media Inc., which provides public radio digital data network services in the metropolitan region, and NEC Corp. have jointly developed a card type radio modem for notebook type personal computers and portable information processing terminal equipment. Simply inserting the card type radio modem into the card slot of a compact personal computer, for example, enables linkage with portable terminals and host computers via the company's communications network.

As long as there is software storing the terminal's identification (ID), this modem enables data communications by radio regardless of the type of notebook type personal computer and portable terminal equipment if the world standard PCMCIA2.0 slot is present, a facility widely used in information processing terminal equipment in general. This is the first time that the radio modem has been made as a monoblock assembly, and it weighs only 220 g, about one-third the weight of the company's conventional products.

The monoblock design that has been introduced enables the card unit mounting the interface circuit and the radio unit including the antenna to be folded into a compact unit, so that the modem can be inserted into the card slot of an information processing terminal even upside down. In addition, it can be folded compactly for convenience during transportation.

The diversity system is introduced to secure a high level of receiving performance as a radio modem, the UM4 alkali battery used is commonly available, and continuous communications for over two hours are possible.

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This radio modem can be used in combination with various information processing terminals. It can be used, for example, as a corporate system for maintaining liaison with sales and maintenance personnel, for business and personal purposes for radio electronic mail, data base access, and personal computer communications services. The modem will contribute immensely to improving business efficiencies, better services, and greater convenience.

As its first venture, the company plans to put on the market in July modem software for use with the NEC compact personal computer. The modem will be sold at a domestic price of ¥ 49,800, the software at ¥ 5,800, and the company anticipates to sell 5,000 modems in the initial fiscal year.

Japan City Media Inc., 4-9-25, Shibaura, Minato-ku, Tokyo 108, Tel: +81-3-5476-8611, Fax: +81-3-5476-8613

#### **Ku-Band High Output Multifinger HBT for Satellite Communications**

*43070118B Tokyo NEW TECHNOLOGY JAPAN  
in English Jul 94 p 25*

[Text] Mitsubishi Electric Corp., Optoelectronic & Microwave Devices Laboratory has developed a heterojunction bipolar transistor (HBT) for satellite communications in the Ku band.

This HBT features a high output of 1 W with a single chip and the power added efficiency is as high as 72 percent, which indicates how much supplied power is effectively usable for RF signal output. Therefore, it is ideal for use in transmission systems such as satellite

communications and satellite broadcasting. The company plans to distribute these HBT samples within two years.

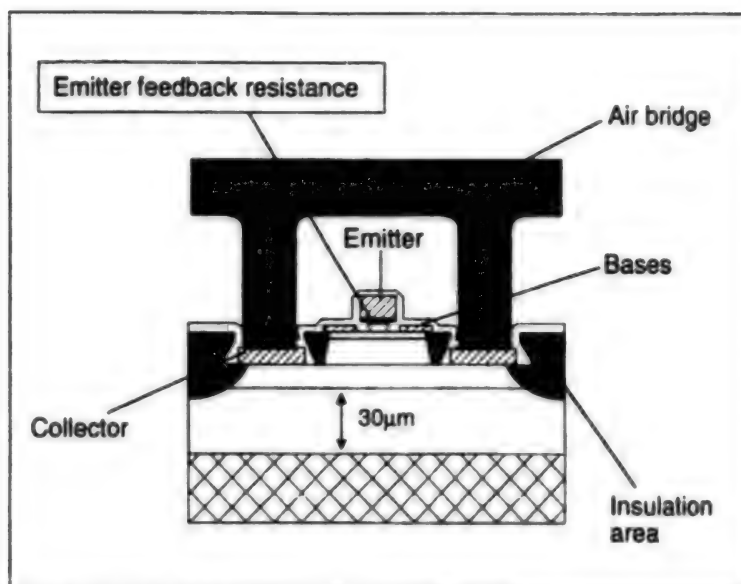
The future introduction of advanced information processing will cause a brisk demand for satellite-to-earth communications, intersatellite communications, and satellite broadcasting. Present power amplifiers for these microwave and millimeter wave communications systems are high-output version travelling-wave tubes, but there is still a need for further development of high-performance solid state HBTs for smaller equipment with increased reliability.

The new aluminum-gallium-arsenide and gallium-arsenide HBTs have a multifingered structure consisting of 10 emitter fingers (emitter size  $1.5 \mu\text{m} \times 20 \mu\text{m} \times 10$  fingers) with a special type of circuit called the emitter feedback resistance circuit to prevent current concentration on the center portion of the fingers. The feedback resistance is composed of the contact resistance at the interface between the contact layer and emitter electrode.

To minimize the parasitic capacitance, the interconnection wire is floated in space (air bridge interconnection), and to reduce the thermal resistance, a plated heat sink (PHS) with  $40\text{-}\mu\text{m}$  thick gold plating was formed on the back of the substrate which is thinned to  $30 \mu\text{m}$ . At the same time, the distance between base electrode and emitter electrode was shortened to further reduce the parasitic resistance and parasitic capacitance. These improvements led to the successful fabrication of HBTs featuring a high output of 1 W and power added efficiency of 72 percent.

The company plans further research to commercialize a 4 W chip that aligns four multifinger cells.

Mitsubishi Electric Corporation, Public Relations Dept., 2-2-3, Marunouchi, Chiyoda-ku, Tokyo 100, Tel: +81-3-3218-2172, Fax: +81-3-3218-2431



Cross section of HBT



Applications of high-output multifinger HBT

### Asia-Pacific Telecommunity Seminar

#### Profile of APT

43070119A Tokyo SCIENCE & TECHNOLOGY IN JAPAN in English May 94 p 38

[Text] Satellites launched by various countries are in stationary orbit at an altitude of 36,000 km above the

equator and are currently used for communications and broadcasting. This immense number of satellites has created a congested satellite thoroughfare, with resultant communications interference caused by the radiowaves generated by these satellites.

Radiowaves mutually interfere and cause difficulties in communications, which should be regarded as a common problem for all nations. To prevent radiowave

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interference among satellites and to enable quality radio-waves to be transmitted from the satellite to earth, it will be necessary to allot satellite frequencies and satellite orbital positions, to preventing an "acquisition" rush above the equator.

The communications satellite necessarily has to undergo a transformation due to the impending multimedia-oriented reorganization proposed by NII (USA). From the technological aspect, the satellite is to carry the radiowave system, among the micronization and network establishment which are the two basic technological trends in the multimedia system. On the ground, digitalization of optical cable networks will proceed, and information will be transmitted through multi-channels backed by advanced technologies for communications highway information compression and regeneration. Therefore, the linkage between communications satellite radiowave systems and ground optical cable systems will be advanced on a larger scale than at present.

However, the large volumes of information pouring into a country from communications satellites across national borders and beyond cultural spheres may not be compatible with the "thoughts or concepts" of the peoples. This is an important pretechnical problem for the progress of advanced technologies. The EC countries, which have sensed this hazard of a new cultural warfare, have adopted a coordinated policy from an early stage. This realism issue, despite the fact that information exchange should be advanced freely, is raising the need for establishing guidelines in information exchange, applicable to EC countries and to Asian countries.

APT Seminar was held on 12-15 April to discuss the "Satellite Communication and Broadcasting in the Asia-Pacific Region." STJ has been able to compile articles including keynote speech transcription by Mr. Masahito Tani, Deputy Minister for Policy Coordination of Ministry of Posts and Telecommunication (MPT) of Japan, thanks to the cooperation of Mr. Takio Yamamoto, Deputy Director, International Cooperation Division, MPT.

#### [Boxed item]

##### Profile of APT

##### Objectives

The Asia-Pacific Telecommunity (APT) was established in May, 1979, as a regional telecommunication organization under the auspices of the Economic and Social Commission for Asia and the Pacific (ESCAP) by an intergovernment agreement.

The APT maintains close cooperation with relevant UN bodies/agencies and international and regional organizations.

The APT Secretariat started functioning beginning 1 July 1979 at Bangkok, the headquarters of the Telecommunity.

The Telecommunity was established to ensure balanced development of telecommunications in the Asia and

Pacific region, at a pace commensurate with the economic and social development of the region, and also to fulfil the needs of:

- a permanent machinery to correlate planning, programming, operation and management of existing and projected telecommunication services within the region;
- a consultative organization for settlement of telecommunication matters which could be more effectively discussed and solved on a regional basis;
- a professional resource in telecommunications within the region itself, constituting an instrument of regional cooperation.

##### Membership

Membership in the Telecommunity is open to any state within the region which is a member of the UN or the ESCAP.

Associate Membership in the Telecommunity is open to any associate member of the ESCAP.

Affiliate Membership in the Telecommunity is open to any provider of telecommunication services to the public within the region and which is nominated by a Member or Associate Member.

##### Organization

The Principal organs of the Telecommunity are:

- The General Assembly
- The Management Committee
- The Secretariat

The General Assembly is the supreme organ of the APT, comprised of all the Members and Associate Members, and which ordinarily meets every three years, establishes general policies and principles to achieve the objectives of the Telecommunity, fixes the basis for the annual budgets and limits of expenditure, concludes and revises necessary agreements, etc.

The General Assembly elects a President and two Vice Presidents at each ordinary session. [End boxed item]

##### APT Seminar Keynote Address

43070119B Tokyo SCIENCE & TECHNOLOGY IN JAPAN in English May 94 pp 39-42

[Article by Masahito Tani]

[Text] The history of satellite communications now exceeds 30 years, and the progress made during these three decades has been astounding. Initially, satellite communications systems were developed as a supplement to terrestrial radio systems and cable systems. On the basis of this remarkable technological progress, however, satellite communications systems have now achieved an independent development status because of the features they offer. Various satellite communications



systems have made their appearance, while system applications have been further advanced and diversified at the same time.

It is clear that the recent trends in internationalization and border-free economic activities have a close relationship with the progress in satellite communications and satellite broadcasting. Moreover, satellite communications and satellite broadcasting have also started to play major roles in terms of economic development within individual countries and/or limited regions.

Under these circumstances, international cooperation and coordination concerning satellite usage have become increasingly important. Furthermore, new tasks have emerged accompanying progress in the convergence of communications and broadcasting. I think, therefore, it is very significant on this occasion to discuss the issues of both satellite communications and satellite broadcasting in order to deepen mutual understanding among the nations of the Asia-Pacific region and to build a closer cooperative relationship among our countries.

Accordingly, I would like to outline Japan's actual approach and thinking concerning the tasks we are currently facing in satellite communications and satellite broadcasting, and hope to provide some reference for our discussions.

#### **Environmental Changes in International Satellite Communications Business**

I would first like to discuss the three major changes that are taking place in the international satellite communications field as a result of recent progress in satellite communications technology, the economic developments in various countries that have facilitated the launching of satellites, the increased purchasing power for receiving equipment, and the increased needs for video information.

To begin with, although international communications satellites have been provided on a monopoly basis by the INTELSAT (International Telecommunications Satellite Organization) in the past, communications satellites provided by private companies that are separate from INTELSAT made their appearance around 1990, and have since been providing international communications service. Many separate satellite communications systems are also planned for the future as well.

The second point is the fact that the U.S. and European countries have admitted that existing carriers can use these separate satellite systems and/or that entities operating separate satellite systems could directly provide international communications service conditioned on technical and economic coordination with INTELSAT.

Third, INTELSAT has now clarified a co-existence approach vis-a-vis other satellites by simplifying coordination procedures with separate satellite systems. Accordingly, separate satellite systems are now being internationally recognized as

satellites that can be used for the international satellite communications business, together with INTELSAT.

#### **Satellite Communications Systems in the Asia-Pacific Region**

These environmental changes in the satellite communications business field are also significant in the Asia-Pacific region. In the wake of the remarkable economic developments in the Asian area, satellite systems currently being operated include PALAPA, OPTUS, ASIASAT and THAICOM, and new satellite systems, such as APSTAR, PANAMSAT, MEASAT and KOREASAT are now in the planning stage.

In light of competition with optical fiber cable, this increase in transponder capacity offered by these satellites will likely intensify competition among various satellite communications systems in the Asia-Pacific region in the future.

#### **Deregulation Policies in Japan in the Satellite Communications Field**

I would next like to discuss the deregulation policies in Japan in the satellite communications field. In addition to the environmental changes previously noted, the following background factors are also behind our deregulation policies.

First, Japan's international communications service users—mainly broadcasting companies which internationally transmit and receive TV programs—have also shown a growing interest in separate satellite systems, and face the need to use these separate satellite systems that permit communications using VSAT (very small aperture terminals) for international communications.

Second, in the light of international trends in satellite communications, Japan's domestic satellite communications carriers also wish to participate in the international communications business as separate satellite systems operating companies.

In order to cope with these environmental changes surrounding satellite usage, the Japanese government announced deregulation policies for international satellite communications in September of last year. Among other things, these new policies enable the following.

The first relates to the usage of separate satellite systems by existing international communications carriers, such as KDD.

The second concerns participation in the international communications field by domestic satellite communications operators in terms of leased-circuit service.

The third relates to participation in the international communications field by foreign satellite communications operators, also with respect to leased-circuit service.

Item 1, which deals with the usage of separate satellite systems by KDD, etc., was allowed at the end of September of last year, and plans have already been started regarding

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the usage of the INTERSPUTNIK and COLUMBIA satellites. With respect to Item 3, which deals with participation by foreign satellite operators in the Japanese market, preparations are now being made to submit bills to the current Diet session that would partially revise the Telecommunications Business Law and the Radio Law to abolish controls over foreign investment. In terms of Item 2, covering participation in the international field by domestic satellite communications operators current plans call for enacting appropriate changes at the same time that the pertinent laws are received.

By means of these structural reforms, we would hope to be able to increase user convenience by making available the diverse and inexpensive international satellite communications services that use the features of separate satellite systems, while at the same time further activating the satellite communications business by expanding market opportunities through meeting the increasing demands for satellite communications.

#### International Television Broadcasting Service

Because of the progress in internationalization, cross-border exchanges in people, goods, information, etc., have substantially increased, leading to ever closer relationships among the various nations of the world. With respect to international information exchanges, various kinds of data have been mutually distributed via international telecommunications for many years. In recent years, however, the development of video telecommunications circuits has enabled the instant transmission of real images. In addition, the international exchange of packaged TV software has also been proceeding at a rapid pace among the countries involved.

In addition to these trends, the continuing rapid advances in satellite technology have also led to progress in so-called "cross-border TV, or international television broadcast." In the Asian region, international television services will soon be provided by a number of countries using satellites in the region. Because of the prominent positions that Asian countries hold in terms of worldwide growth rates, remarkable developments can also be expected in the field of international television broadcasting in the future as well.

While international television broadcasting service in Europe is executed under mutually recognized standards, no such international rules exist in the Asia-Pacific region. Moreover, because of the wide divergence in social and cultural conditions among Asian and Pacific nations, we may run into problems in trying to develop standards that would cover the entire region. Nevertheless, it is recognized that the establishment of certain common understandings may be necessary for the smooth development of international television broadcasting in the Asia-Pacific region.

Because the field of international television broadcasting has been adopted as one of major issues to be explored in the satellite seminar starting today, I hope that these discussions will be particularly fruitful in this regard.

#### Diversification in Satellite Usage

Space communications in Japan has a history of more than 20 years since the early development of communications satellites (the CS series) in 1973. As we would expect, the evolution of this process has gone through a number of stages, including development, experimental applications and actual usage, prior to the current stage of dissemination and promotion in order to expand and diversify usage as a new medium that will enhance lifestyle options.

In addition to the CS-3 satellite launched in 1988, a number of private companies have also launched satellites since 1989, including the JCSAT-1 and 2 operated by the Japan Satellite Systems Inc. and the SUPERBIRD A and B satellites launched by Space Communications Corporation. These satellites have come in for increased usage on an extensive-area basis, such as SNG (satellite news gathering), CATV program distribution event relays, intracompany education, etc., which rely on satellite communications features such as simultaneous reception, expanded service area, and flexibility in setting up circuits. Moreover, new services have also been started since last year such as, the mobile communications business by OmniTRACS Corporation, which combines satellite positioning using GPS (global positioning system) and satellite communications.

In the future as well, NTT and Japan Satellite Systems Inc. are planning to launch new satellites by 1995. These new satellites will bring about further diversification in satellite communications usage such as, NTT's N-STAR system which will provide for better mobile satellite communications service.

With respect to broadcasting satellites NHK is now providing two channels and WOWOW ordering one channel via the BS-3 broadcasting satellites launched in 1990 and 1991. Furthermore, the world's first Hi-Vision (or HDTV) experimental broadcasting was started in November 1991.

With the 1989 revisions of the law to allow for PCM-voice and TV broadcasting via communications satellites, offerings of this type started appearing in succession in 1992. Currently 10 channels of TV broadcasting and 12 channels of PCM-voice are available.

Through this long development stage until satellite communications and satellite broadcasting were commercialized, Japan's Ministry of Posts and Telecommunications exerted its utmost efforts towards the development of satellite and satellite-utilization technology. Moreover, the ministry also provided extensive support via governmental financial investment tax relief to encourage the start of space communications businesses, which naturally involve high risks and substantial costs.

In order to adequately respond to the advanced applications in space communications as we move towards the 21st century, it is necessary to proceed with R&D work in new technologies, such as advanced mobile communications

technology, advanced satellite broadcasting technology and inter-satellite communications technology. At the same time, it is also necessary to develop an overall environment in which to disseminate and promote the usage of space communications.

#### Effective Utilization of Frequencies and Satellite Orbits

Article 33 of the International Telecommunications Convention stipulates that "frequencies and geostationary orbits are limited natural resources, and consideration should be given to their fair usage by countries or country groups." The article further notes that such resources must be "efficiently and economically" used.

The reason for limited geostationary orbits is the need to secure appropriate orbital spacing as satellites using the same frequencies in nearby orbits can lead to mutual signal interference.

There has, however, been a rapid diffusion and development in satellite communications because such applications are not limited to international communications, but are also used for domestic communications within limited areas. Currently, about 250 satellites are registered with ITU's international frequency register. Moreover, future plans call for the launch of about 600 new satellites.

Roughly speaking, this could mean an extremely congested status in which an average of two to three satellites are located in each geostationary orbital slot (1° intervals). If this congestion continues, it is expected that mutual interference and disturbance may frequently occur, and that such problems may compromise the stable and efficient use of geostationary satellites.

In order to deal with this situation various technologies have been developed that permit efficient satellite usage in the highly congested environment that may ensue. These include the improvement of antenna characteristics, and the development of systems to overcome high-level interference. In addition, all efforts should be made to improve measures to deal with mutual interference.

Despite such measures, however, it is considered impossible to introduce and operate as scheduled all of the global satellite networks that have so far been announced.

In order to improve this situation, it is necessary to adopt a cooperative posture, such as imposing restrictions on power supply, service areas, etc., in the course of international coordination procedures for satellite communications networks, and mutually permitting a certain degree of interference (degradation of circuit quality).

Moreover, the cooperation of various countries towards the development and usage of the Ka-band and other frequencies as well as efforts to review or integrate competing satellite plans themselves, should be seen as urgent global tasks.

In view of this situation, we would hope to continue the close cooperative relationships that have already been developed among all countries involved. As one of the Asian

and Pacific countries with many satellite plans for the future, Japan hopes to build on the close cooperative relationships and trust we have already achieved among those countries concerned, and to continue working with other countries in sincere approaches towards the effective usage of frequencies for satellite communications in geostationary orbits.

#### Closing

I have so far mainly discussed the recent situation surrounding satellite communications and satellite broadcasting in Japan. However, there are many tasks still remaining in this rapidly growing field. These are issues that face not only our country, but are also matters that many other countries are making similar efforts to resolve. Most importantly, these are not tasks that can be handled by any one country alone; rather close cooperation is important among regions and among related countries.

I hope this seminar will contribute to deepening the regional cooperation through the active exchange of views and opinions on various themes concerning satellite communications and satellite broadcasting in the Asia-Pacific region.

*This article is a transcription of the keynote address delivered at APT Seminar by Masahito Tani, Deputy Minister for Policy Coordination of Ministry of Posts and Telecommunication of Japan.*

#### Outline of APT Seminar

43070119C Tokyo SCIENCE & TECHNOLOGY IN JAPAN in English May 94 pp 42-45

[Text] The outline of Asia Pacific Telecommunity (APT) Seminar, which took place 12-15 April, is reported in this article. The themes discussed and guidelines included are outlined here.

1. A Seminar on Satellite Communications was organized by the Asia-Pacific Telecommunity from 12 to 15 April, 1994 in Tokyo, Japan. The Seminar was hosted by the Ministry of Posts and Telecommunications, Japan.

The main objectives of the Seminar were:

- To address the key issues involving policy, regulatory and technological aspects of satellite communications and business trends with special reference to the Asia-Pacific region.
- To exchange views on the significance of international television broadcast services, and the need for a common guideline for TV programme contents and regulatory matters in the Asia-Pacific region.
- To strengthen regional cooperation in proper utilization of satellite technology for broadcast and telecom applications.

2. 125 participants from APT members, associate members, affiliate members, international organizations and others attended the Seminar. A list of participants is placed at Annex 1 [Annex not reproduced].

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3. Mr. Hiroyasu Sonoki, Executive Director of APT, delivered the welcome address. Mr. Sonoki referred to the rapid technological advancements in the field of satellite communications, its increasingly important role in enhancing the provision of voice, video and data services. Mr. Sonoki explained that according to the ITU definition, telecommunication also includes broadcast services. It is, therefore, necessary to address all issues related to communication and broadcast services including the regulation of television broadcasts and their programme contents.

4. H.E. Mr. Aogu Matsumae, Parliamentary Vice-Minister, Ministry of Posts and Telecommunication of Japan delivered the inaugural address in which he stressed upon the need to develop regional cooperation among the countries of the Asia-Pacific region for promoting the growth of satellite communication in a fair and efficient manner. He also said that the welcome growth of communication and broadcast services should be complemented with an effort to utilize these services in the most beneficial manner. The texts of the statements are placed at Annexes 2 and 3 [Annexes not reproduced] respectively.

5. The following persons were unanimously elected as office bearers of the Seminar:

Chairman: Mr. Yoshio Utsumi, Director General, Ministry of Posts and Telecommunications, Japan

Vice Chairman, International TV Broadcast Service: Mr. Nurhadi Subroto, Secretary, Directorate General Radio-TV-Film, Ministry of Information, Indonesia

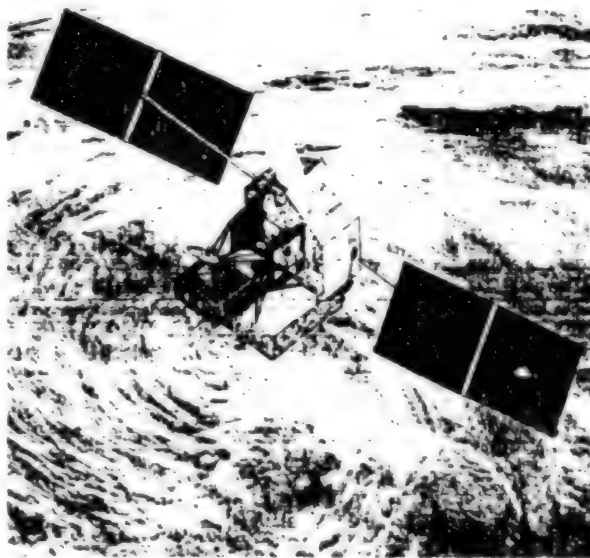
Vice Chairman, Satellite Communications: Mr. Akhtar Ahmad Bajwa, Chief Engineer (International Communication), Pakistan Telecommunication Corporation

Chairperson Drafting Committee: Ms. Consuelo Perez, Deputy Commissioner, National Telecommunications Commission, Philippines

6. The proposed agenda (revised) for the seminar was approved.

7. Mr. A. Narayan, Director, Project Development of APT, presented the background paper in which he described the present scenario of satellite communications in the region, the issues involved in promoting the applications of satellite technology in communications and broadcast sectors and the role of APT in promoting regional cooperation in satellite applications.

8. Mr. G.C. Brooks, Member, Radio Regulation Board of ITU, described the ITU regulatory procedures for satellite networks. Mr. Brooks said that goodwill and co-operation of ITU member administrations is the key to successful implementation of the regulatory procedures. The choice with us is either to honor these regulations in letter and spirit or to land ourselves in a chaotic situation. Mr. Brooks said that obviously all of us will unanimously agree for the first option.



9. Mr. Naohiro Kato, Director, Programme Department, Asia-Pacific Broadcasting Union (ABU), discussed the regional transnational broadcast services, particularly the emergence of regional satellite broadcasters from the Asia-Pacific region. Mr. Kato described the present and planned satellite broadcast services in the region and also informed the participants about the recommendations of an ASEAN Regional Seminar on Transnational Satellite Broadcasting, held in Kuala Lumpur from 4 to 6 April 1994. The Seminar has made some useful recommendations for promoting sub-regional co-operation on improving programme quality, code of ethics and programme exchange among concerned broadcasters.

10. The keynote address was delivered by H.E. Mr. Masahito Tani, Deputy Minister for Policy Coordination, Ministry of Posts and Telecommunications, Japan. In his keynote address, H.E. Mr. Tani described the importance of satellite technology and services in the present environment and said that in view of the recent increase in satellite applications, careful consideration has to be given for issues involving domestic and international satellites, orbital allocation, efficient utilization of frequency spectrum, convergence of telecommunications and broadcast services, etc. Mr. Tani said that recently many countries in the Asia-Pacific region have started receiving transborder broadcasts. International television broadcast services have their own merits and demerits and each country should analyse these aspects in accordance with its own domestic policy. H.E. Mr. Tani described some of the latest policy and technological developments in Japan. He also stressed upon the need to strengthen cooperation for promoting the applications of satellite technology in the region.

11. After the session on the overview, the deliberations were held in the following two parallel sub-committee sessions.

- a. Satellite Communications, and
- b. International Television Broadcast Service



The Sub-Committee on Satellite Communication was chaired by Mr. Akhtar Ahmad Bajwa and the Sub-Committee on International Television Broadcast Service by Mr. Yoshio Utsumi.

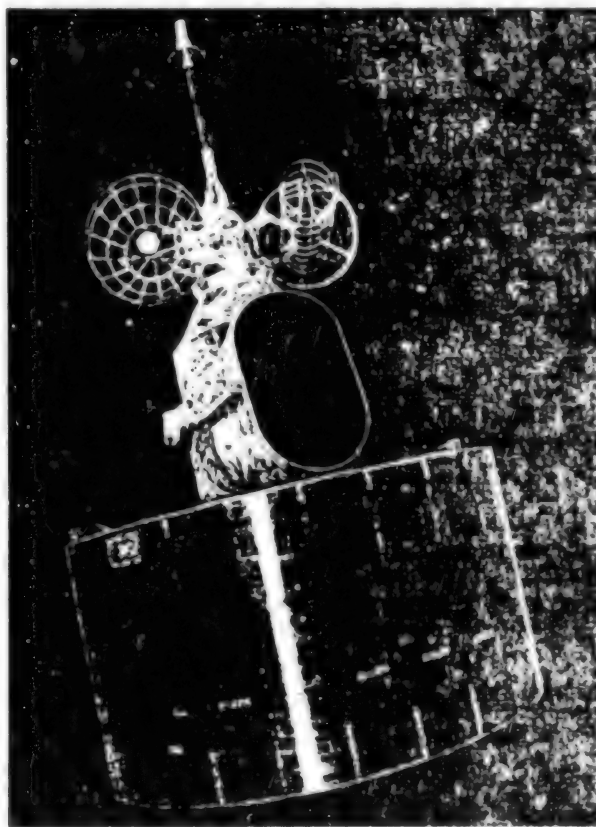
12. A number of papers covering telecommunication and broadcasting aspects were presented in the Seminar. Study tours to telecommunication and broadcast facilities were also organized.

13. The reports of the sessions on:

- a. Satellite Communication, and
- b. International TV Broadcast Service

were presented and approved in the plenary.

The reports of the Sub-Committees are attached.



#### 14. Conclusions

The following conclusions were drawn:

##### (1) Satellite Communications Sub-Committee

- Recent advances in satellite technology have significantly enhanced its application in communication and broadcast sectors. Satellite technology is playing a

major role in globalization of telecommunication and broadcast services.

- In the Asia-Pacific region, some countries have already launched their own satellites and have gained a high level of expertise in satellite technology. Other countries of the region are studying the various options available with them for meeting their present and projected requirements either by their own satellites or by utilizing the satellites owned by other operators.
- It is recognized that the main issues before the developing countries of the Asia-Pacific region are whether to have their own satellite systems or to use the existing one or to use a combination of both.
- There is a need to promote free and frank exchange of views among the various partners and players involved and APT's efforts in organizing this important Seminar are greatly appreciated. It would be useful to have part of a seminar in 1995 devoted to the regional preparations for the 1995 ITU, WRC, particularly for matters dealing with possible improvements to the ITU satellite regulatory process.
- The developing countries of the region should be able to adopt the latest technology and there is a need to strengthen the appropriate mechanism for promoting the adaptation of latest technology in their countries.

##### (2) International TV Broadcast Service Sub-Committee

- While the European Union has got a well established and agreed legal framework for the regulation of the broadcast programmes within its member satellites, it was recognized that the mechanism would be very difficult to introduce in the Asia-Pacific region considering the diverse culture, social values, and economic conditions existing in the region.
- It was agreed that some form of guideline is essential to promote the harmonious development of this service in the region.
- While formulating such a guideline, it was the consensus that special consideration be given to the following points.

- a) Principle of Free-Flow of Information.
- b) Respect for sovereignty, national security and other important or sensitive issues of receiving countries.
- c) The need to protect the interest of minors (children).
- d) Respect for social, political, cultural and traditional values of countries of the region.
- e) Respect for the diversity of various opinions.
- f) Respect for religion.
- g) Restriction of immoral material and display of excessive violence.
- h) The need for balanced, non-sensational, unbiased and undistorted news reports.
- i) Consideration of copyright issues.

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- With regard to the responsibility for the programme content, it was agreed that there should be at least one country which would be responsible for the content of the program. Various opinions were expressed concerning the location/country which should be responsible for the contents emanating from the following:

- Programme Provider
- Programme Compiler
- Operator of Up-Link Earth Station
- Operator of Satellite

- Many members felt that the country where the programme compiler is located should be the responsible country for the contents of the program.
- With regard to the preparation of the guideline, it was the consensus that such a guideline should be:

(i) as a first step in the form of Recommendation or Resolutions and not in the form of a binding Instrument or Convention.

(ii) with minimum basic principle including a common "Code of Ethics" which could be acceptable to all countries.

(iii) a broad framework for voluntary adherence without too much detailed directives which should be left to self-regulation by individual broadcasters.

#### 15. Recommendations

The following recommendations were made.

##### (1) Satellite Communications Sub-Committee

- Respective member administrations take necessary steps to strengthen regional cooperation in frequency planning and orbital slot allocation for making the optimum utilization of these finite natural resources.
- Respective member administrations create conducive policy and regulatory environment to promote the applications of satellite technology for meeting their present and future requirements.
- Respective member administrations make all possible efforts to create an infrastructure and mechanism for adaptation of the latest technology appropriate for meeting their national, sub-regional and regional requirements.
- APT plans and implements suitable projects for promoting dissemination of information, exchange of views, transfer of appropriate technology and cooperation among the countries of the region on an ongoing basis. Concerned regional and international organizations are also requested to cooperate with APT in meeting these requirements.
- APT assists member countries, in cooperation with the ITU and other organizations, in the development of satellite plans for the region and in the satellite coordination process.

##### (2) International Television Broadcast Service Sub-Committee

- Member countries examine the issue of a guideline in promoting multilateral cooperation, and designate a contact point for coordination and follow-up.
- APT organizes future meetings for further discussion in order to formulate a general guideline on the program content of the international satellite television broadcasting in Asia and Pacific region, taking into account, in particular, the following points.

a) Principle of Free Flow of Information.

b) Respect for sovereignty, national security and other important or sensitive issues of receiving countries.

c) The need to protect the interest of minors (children).

d) Respect for social, political, cultural and traditional values of countries of the region.

e) Respect for the diversity of various opinions.

f) Respect for religion.

g) Restriction of display of immoral material and excessive violence.

h) The need for balanced, non-sensational, unbiased and undistorted news reports.

i) Consideration of copyright issues.

- Member countries consider the modalities for the application of such a future guideline within their respective national regulatory framework pertaining to satellite broadcasting in an appropriate manner.

#### Space Communications Policy in Japan

43070119D Tokyo SCIENCE & TECHNOLOGY IN JAPAN in English May 94 pp 45-46

[Article by Hideharu Sasaki]

[Text] Space communications is a wireless medium boasting such characteristics as wide-area coverage that enables the provisioning of services across a vast area and multi-casting capability that permits the simultaneous transmission of information from a single satellite to a large number of terrestrial-based stations, making possible the construction of mobile, flexible networks and high-capacity communications.

To further the deployment of more advanced information-communications networks as the 21st century nears, we must marshal to best utility and vigorously employ the inherent advantages boasted by space communications.

To this end, concurrent with the mustering of resources targeted on promoting the widespread use of satellite communications and broadcasting and expanding the range of fields utilizing such services, a continuing program of research and development of leading-edge space communications technologies must be advanced in order to build an easy-to-use satellite communications system furnishing enhanced customer conveniences.

### Expanding and Promoting the Use of Space Communications

In addition to Communications Satellite 3 (CS-3a and 3b) and Broadcasting Satellite 3 (BS-3a and 3b), there are four private communications satellites currently operating in Japan: JCSAT-1 and 2 owned by Japan Satellite Systems Inc. (JSAT) and SUPERBIRD A and B owned by Space Communications Corp. (SCC). Considering launches scheduled in the near future—the BS-3N, in fiscal 1994; the N-STAR a and b and the JCSAT-3, all in fiscal 1995; the BSAT-1a, currently in fiscal 1997; and the BSAT-1b, in fiscal 1998; not to mention that of Space Communications' SUPERBIRD C—Japan can be said to have entered an era in which it is engaged in full-scale satellite business activities.

Examples abound of applications employing the services provided by space satellite communications and broadcasting including 1) applications taking advantage of satellites' inherent disaster resistance, such as their use to provide temporary and back-up links for terrestrial-based circuits; 2) applications taking advantage of their wide-area coverage and multi-casting, such as commercial satellite broadcasting, distribution of cable television programs, and in-company use (in-house education and information activities, inter-enterprise video-conferencing, etc.); and 3) applications taking advantage of their flexibility in establishing communications channels, such as wide-area relaying of event broadcasts and satellite news gathering (SNG). Recent trends that can be cited include the launching of many new services, such as satellite-based "tele-classes" being popularized by preparatory schools and the combining of satellite geopositioning and terrestrial-based mobile data communications services provided by Omni TRACKS Corporation. Moreover, mounted on the N-STAR satellites scheduled to be launched in 1995 are mobile satellite communications transponders for maritime coverage of vessels located in the seas within 200 nautical miles of Japan, all furnishing indications are that the use of satellites will continue to become increasingly diverse.

If, as described above, one can truthfully and with certainty state that the use of satellites is expanding, that person would undoubtedly be hardpressed to declare that satellite communications businesses are cruising along the fast track. To help remedy this situation, in an effort to lighten the burden occasioned by the initial investment required for such projects, the Ministry of Posts and Telecommunications (MPT) in 1984 began extending to satellite communications and broadcasting providers favorable governmental financial investment and tax relief to make available funds for the acquisition of satellite communications, broadcasting and management facilities. To promote the growing use of satellites, the MPT also furthers knowledge dissemination activities through such actions as providing support for the activities of Satellite Communications Promotion Council of Japan and backing for satellite communications-related symposia. Moreover, with the cooperation

of communications and broadcasting providers the MPT conducts testing using the CS-3, BS-3 and Engineering Test Satellite V (ETS-V) with the objective of developing technologies for utilizing satellites and accumulating related expertise.

In conjunction with extending our full support in the domain of governmental financial investment and tax relief and providing backing for knowledge dissemination activities, the MPT also plans to promote development of a diverse array of applications through such activities as applied testing of satellite communications through the use of Engineering Test Satellite VI (ETS-VI) scheduled for launch this fiscal year.

In addition, to construct a convenient, low-priced space communications system incorporating high reliability, the MPT is promoting research and development of space communications as described in the following section.

### Research and Development of Leading-Edge Space Communications Technologies

Until now, in addition to the development of communications satellites (CS) and broadcasting satellites (BS) for testing, communications satellites CS-2 and 3 and broadcasting satellites BS-2 and 3 have been developed through the marshaling by National Space Development Agency of Japan (NASDA) of required funds from government and private users with the aim of developing satellites and making them available for practical use. In addition, the Engineering Test Satellite series of satellites have been developed with the goal of developing satellite shared-use technology.

However, because the arrangement in 1990 between the governments of Japan and the United States proscribed the use of government-developed satellites for commercial purposes or for the provision of services on a regular basis and specified that procurement of non-R&D satellites by government or government-related organizations must be conducted under procedures that are open, transparent and non-discriminatory, satellites for research and development are currently being developed.

A few of the programs the MPT is undertaking are described below:

- (1) Development of testing equipment required for inter-satellite communications testing using ETS-VI scheduled for launching in fiscal 1994;
- (2) Promotion of the development of the Communications and Broadcasting Engineering Test Satellite (COMETS) in fiscal 1996, with the objective of developing such applications as (a) advanced mobile satellite communications technologies employing the Ka and millimeter wave bands with a view to accommodating the increasing diversity of satellite-based mobile communications, (b) advanced satellite broadcasting technology to make possible future wide-area digital high-definition television (HDTV)

broadcasts and Integrated Services Digital Broadcasting (ISDB), and (c) advanced inter-satellite communications technologies that can support large-capacity inter-satellite communications;

- (3) Research and development of next-generation R&D satellites in the fields of communications and broadcasting with the objective of conducting R&D and space-based testing and verification of technologies required to implement mobile satellite communications and mobile satellite digital broadcasting that make possible the use of portable terminals.

Looking to the coming years as well will witness the MPT ceaselessly continuing to promote the development of new technologies to support advanced needs, such as the development of infrastructural technologies for space communications systems and advanced mobile satellite communications technologies and advanced broadcasting technologies, the implementation of advanced management and control systems permitting the use of unemployed frequencies in order to cope with the congestion of geostationary orbit and frequencies to permit the use of low earth orbit and intermediate circular orbit and other activities of this nature.

The MPT is also promoting technologies that enhance the reliability of space communications systems and make possible their stable operation as well as survey and research on the deployment of space infrastructures.

*This article was prepared by Hideharu Sasaki, Ministry of Posts and Telecommunications of Japan, as resume for the APT Seminar.*

**List of Technological Subjects at APT Seminar**  
43070119E Tokyo SCIENCE & TECHNOLOGY IN JAPAN in English May 94 pp 47-52

[Article by Koichiro So]

[Text] Technological themes in the fields of communications and broadcasting discussed at the seminar is listed in this article. Implementation of satellite coordination and improvement of frequency or satellite orbit utilization efficiency are the main themes.

#### Current Operational and Planned Satellite Communications Networks in Japan

##### (1) Use of geostationary satellites in Japan

Japan currently uses six communications satellites, two broadcast satellites, three meteorological satellites and one engineering test satellite. Moreover, in the works are numerous satellite-home communications networks such as the one that will be provided by N-STAR, the successive satellite to the CS-3 series, and satellite projects scheduled to provide international services reaching Asia and across the Pacific.

**Geostationary Satellite Network**

Service	Name	Long	Freq. Band	ITU status
Communication	CS-3a/3b	132E/136E	C/Ka	Notification
	JCSAT-1/2	150E/154E	Ku	Notification
	SUPERBIRD-A/B	158E/162E	Ku/Ka	Notification
	N-STAR-a/b	132E/136E	S/C/Ku/Ka	Coordination
	JCSAT-3A/3B	128E/124E	C/Ku	Coordination
	SJC-1/2	120E/124E	C/Ku	Coordination
	N-SAT-110	110E	Ku	Coordination
Broadcast	N-SAT-128	128E	C/Ku	Coordination
	N-SAT-146	146E	C/Ku	Coordination
	SUPERBIRD-C/C2	144E/146E	C/Ku	Advance Pub
	BS-3a	110E	Ku(plan)	Notification
	BS-3b	110E	Ku(plan)	Notification
	BS-3N	109.85E	Ku(plan)	Advance Pub
Meteorology	GMS-4	140E	UHF/S/C	Notification
	GMS-160E	160E	UHF/S/C	Notification
	GMS-120E	120E	UHF/S/C	Notification
Experiment	ETS-V	150E	L/S/C	Notification
	ETS-VI	154E	S/C/Ku/Ka	Coordination

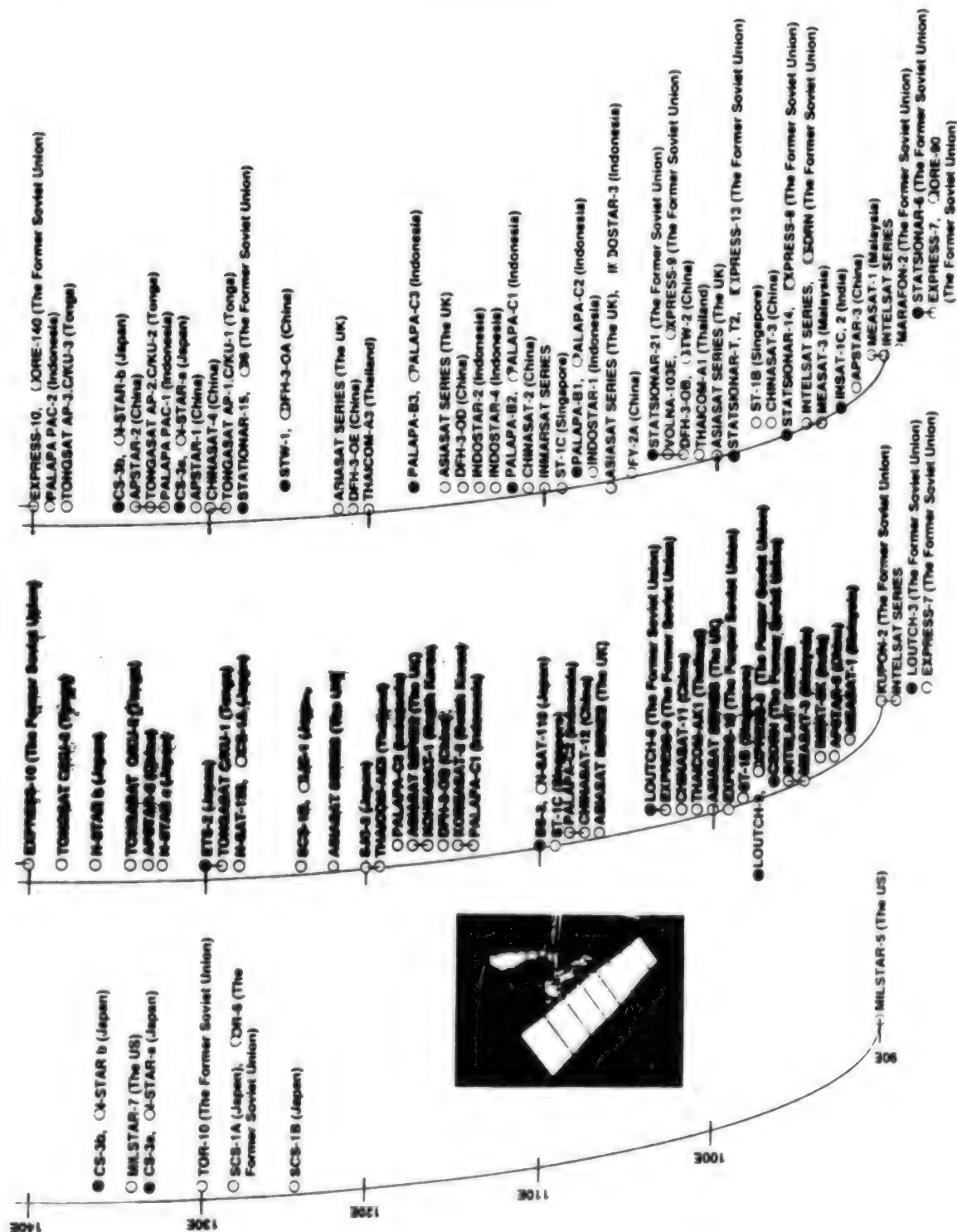


## (2) Use of non-geostationary satellites in Japan

Numerous satellites are being used for observing space and exploring earth, and many more are planned.

Non-Geostationary Satellite Network			
Service	Name	Freq. Band	ITU Status
Space Observation	SOLAR-A	S/X	Notification
	ASTRO-D	S/X	Notification
	EXOS-D	S	Notification
	MS-T5	S	Notification
	SINSEI	UHF	Notification
	GEOTAIL	S/X	Notification
	SFU	S	Notification
	MUSE-B	S/Ku	Advance Pub.
Earth Exploration	MOS-1b	UHF/S/X	Notification
	JERS-1	L/S/X	Notification
	ADEOS	UHF/S/X/Ku	Advance Pub.
Amateurs	JAS-1B	UHF	Notification

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### Current Situation With Respect to the Use of and Plans for Satellites in the Asia-Pacific Region

- (1) Current situation with respect to satellite utilization and plan near Japan
- (2) Use of geostationary satellites over the Asian region

There are 101 satellites in 50 orbital slots registered in the position from 70 to 180 east longitude.

Another 175 satellites in 90 orbital slots are planned and published to be placed in the position from 70° to 180° east longitude.

### Interference Problems in Satellite Communications Network

- (1) Tendencies in the use of geostationary satellites and associate problems

(a) From the monopolistic use of INTERSAT satellites to the commingled use of non-INTERSAT satellites  
The ability to use non-INTERSAT satellites has spawned numerous regional satellites usage projects.

(b) Problems due to the increase in satellite projects  
Increase in satellite coordination has become more difficult and the number of coordination-requiring cases has increased.

Before	Now	Problem
Small to medium sized satellites	Large satellites	
Domestic service	Regional service	Expansion of usable orbital spacing
Single beam	Multi-beam	Expansion of usable orbital spacing
Fixed beam	Steerable beam	Expansion of usable orbital spacing
Single band	Multi-band	Reduction of utilized frequencies

Many satellites that use identical orbital position or frequencies are planned, and orbits are becoming over-populated.

### Japanese Efforts Toward Implementing International Coordination

- (1) Coordination with nations bound to Japan by telex and facsimile links

The increase in satellite usage and the increasing complexity of such usage is making coordination based on document exchange alone increasingly difficult.

- (2) Bilateral coordination

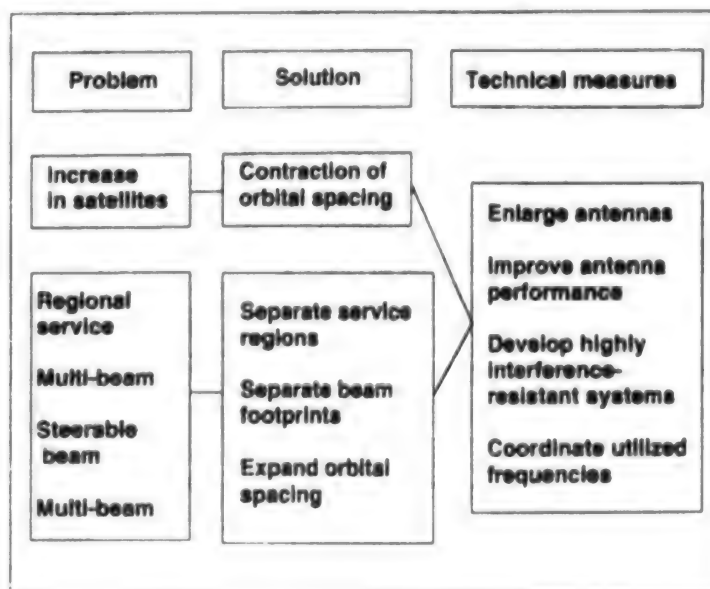
Japan had a bilateral coordination meeting with the USSR for the first time in 1982.

This bilateral coordination meeting proved to be an extremely effective method of coordination, and a total of 18 conferences have been held to date.

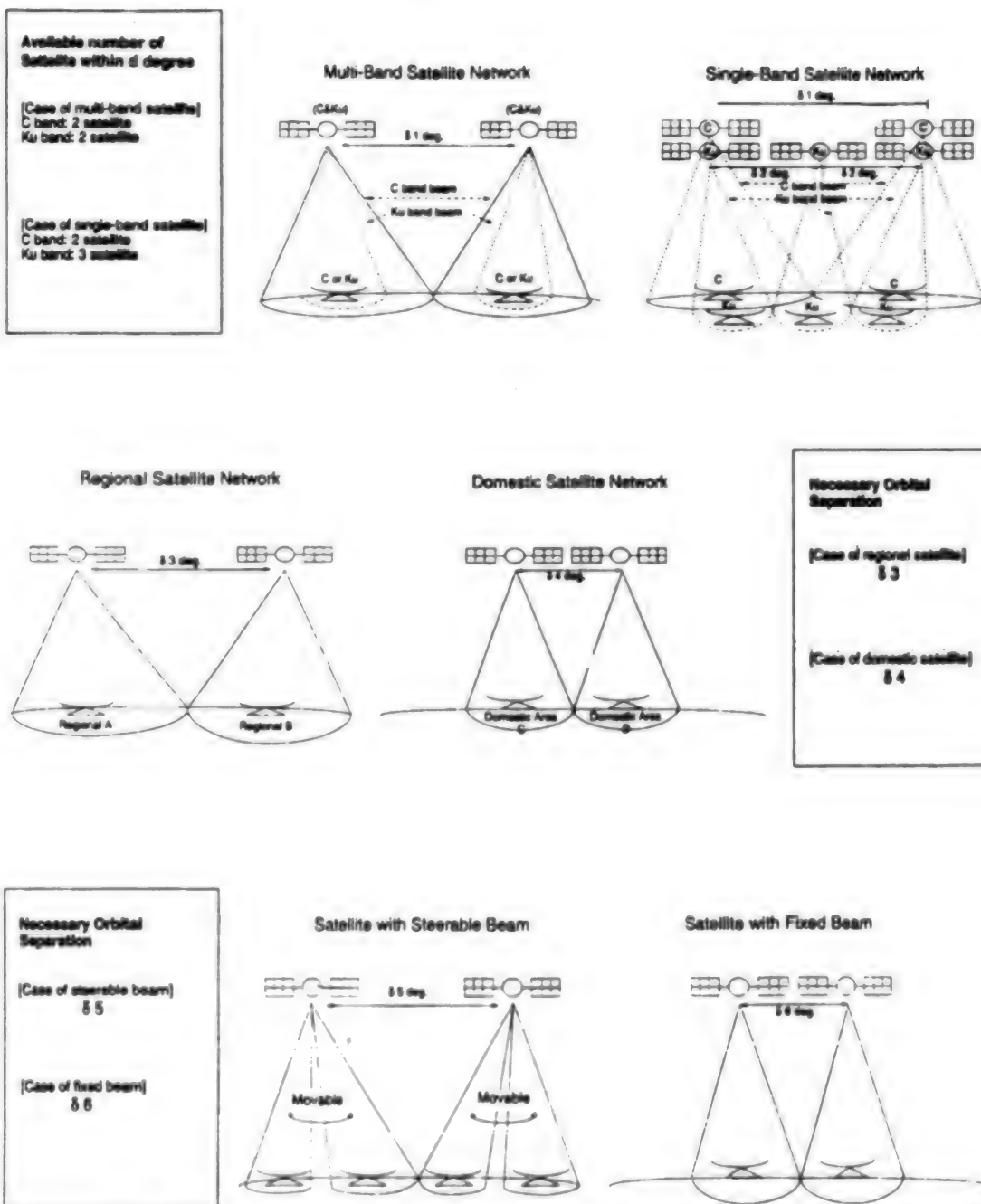
### Toward Future Expansion of Satellite Usage

- (1) Because difficult problems will arise with the increasing number of satellites and diversification of their use, it is essential to actively promote solutions for development of satellite usage.

- (2) Measures to cope with the increase in demand for satellite usage







#### a. Technical measures

##### (a) Development of technology for sharing orbits and frequencies

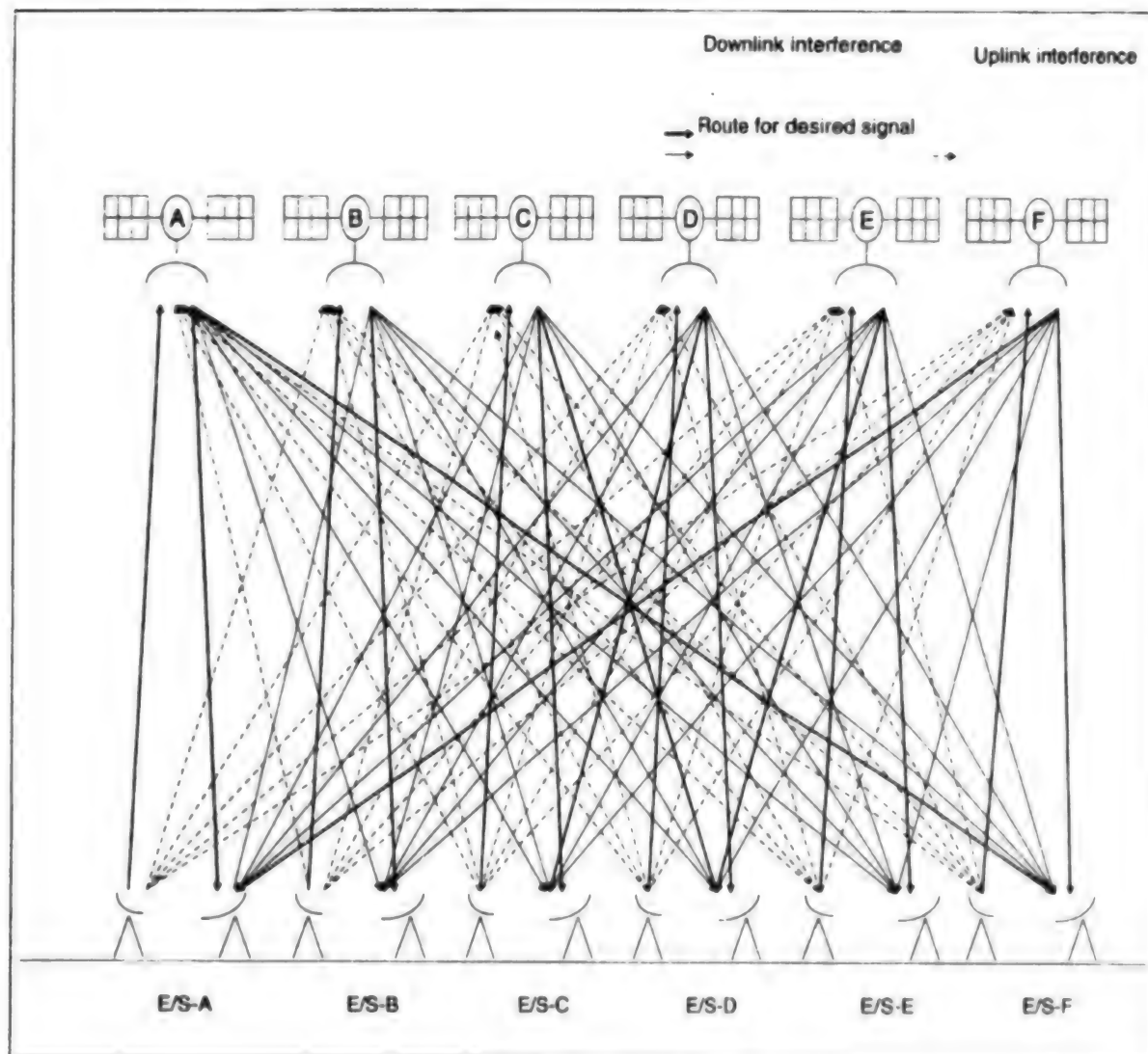
- Development of highly interference-resistant systems (digitization)
- Development of antennas with low side-lobe (performance improvement)

- Employment of currently un-utilized frequency bands (use of the Ka band)

##### (b) Coordination based on technical characteristics

- Reduction in power of interfering earth stations
- Increase in power of interfered earth stations
- Interference reduction by cross polarization

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**Interfering Route Among Adjacent Satellite Networks**

- Improvement through energy dispersal

b. Satellite operating measures

- Coordination on satellite operation times

- Coordination on restricting the service areas

- Coordination on restricting the locations of interfering earth stations

c. Japan-based technical development

Technical development based on engineering test satellites and support technical development pursued by private enterprise.

- Development of digital systems

- Development of high-performance antennas

- Development of unused frequency bands

(3) Promotion of satellite coordination through building of closely cooperative and trusting relationships with related countries

a. The use of all currently planned satellites as specified is extremely difficult, even counting on advancements in technical development.

b. Required is the building of closely cooperative and trusting relationships with related countries with a view to promoting coordination based on mutual concession to enable the use of numerous satellites.

*This article was prepared by Koichiro So, Ministry of Posts and Telecommunications of Japan, as resume for the APT.*

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### Advanced Telecommunication Systems Set To Support the Age of Multimedia

43070202A Tokyo HITACHI TECHNOLOGY 94  
in English Jun 94 p 8

[Text] What is multimedia? This question is at the center of corporate and private research programs around the world. Despite all of the haggling over details, however, one thing is sure: telecommunications are playing the central role in efforts to bring us into the much talked about "age of multimedia." Furthermore, thanks to the successful development of two innovative systems, Hitachi is preparing to enhance its presence in the very lucrative global telecommunications market.

In a recent interview at Hitachi's Totsuka plant, Hiroyuki Fujita and Setsuo Takahashi, senior engineers in the Telecommunications Division, talked about the new systems they helped develop.

#### AMS 5000—Linking the Networks of Tomorrow

Optical data transmission networks allow control systems in different locations to send and receive data, video and voice information through optical fiber connections. Several types of network systems are available but the lack of a single technological standard made it difficult, expensive, and sometimes impossible to span information bases.

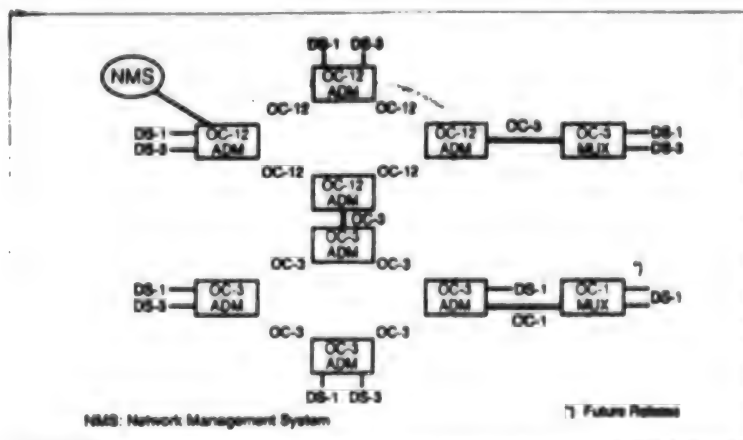
Hitachi solves these and other problems with its AMS 5000, a compact, easy-to-use network system that conforms to the SONET (Synchronous Optical Network) standard adopted by the American National Standards Institute (ANSI). The AMS 5000 has capabilities that previously required a variety of asynchronous equipment and substantial investments. The AMS 5000 supports wide-area networks (WANs), which connect client-server local-area networks (LANs), and are much in demand from companies and businesses.

In designing the AMS 5000, stress was placed on an easily adaptable system architecture. This system uses ATM (Asynchronous Transfer Mode) technology to handle information transfers of variable band width. For example, the AMS 5000 supports existing DS-1 (1.5 Mbit/s) and DS-3 (45 Mbit/s) asynchronous interfaces but can also accommodate the newest synchronous interfaces. The AMS 5000 is easily expandable; as information traffic increases, the user simply adds modules close to customer locations and directs them through a high-performance switching module. The AMS 5000 concentrates and switches as many as 20 DS-3 asynchronous interfaces into 155 Mbyte/s fiber-optic links. With the simple addition of an expansion model, up to 32 such links can be combined into a very-high-speed switching matrix.

The AMS 5000 is perfectly suited to ring networks. Whereas tree networks are severely hampered if one branch goes down, through ring networks the AMS 5000 automatically reroutes information if a link fails.

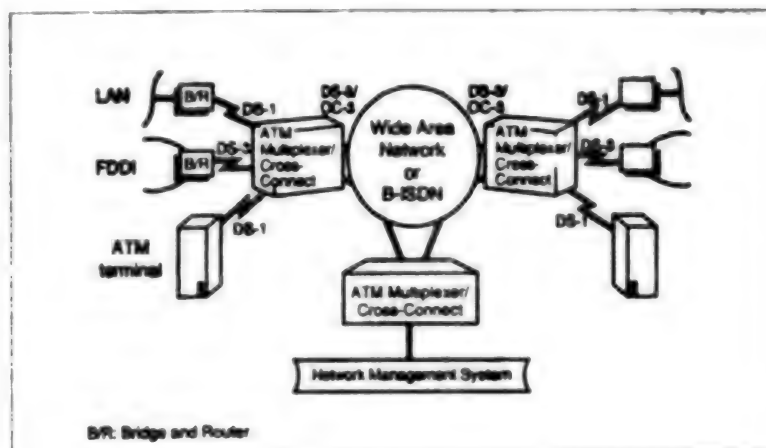
Hitachi's expertise in the field of LSIs facilitated a product design focusing on high density, power efficiency, simple installation and easy maintenance. The AMS 5000 self-monitors its performance, ensuring constant high quality and service reliability. As a result, this system has a noticeably improved survivability rate.

The optional AMS 5000 Network Management System (NMS) provides the kind of flexible controls that realize the full richness of ATM services. The AMS 5000 NMS lets the user control communications between the network operations center and all network elements. Bandwidth optimization features make it possible to allocate bandwidth and services on a per-user basis. In addition, as network conditions change, traffic is maximized thanks to superior congestion control and rerouting capabilities.



Hitachi SONET Networking System

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### Hitachi ATM Multiplexer-Cross-Connect System

#### ATM Multiplexer/Cross-Connect System

To provide an efficient and cost-effective means of transmitting optical data both on existing systems and media of the future, Hitachi has developed the AMT (Advanced Multiservice Transport) 5003. This product breaks technological barriers and offers flexibility, expandability, a compact size, high performance, ease of operation, and excellent cost effectiveness.

AMT 5003 capacity and functions can be expanded simply and easily by adding or replacing circuit modules. As a result, this system can operate as a broadband access node to connect WANs, broadband-Integrated Services Digital Networks (B-ISDNs), Metropolitan Area Networks (MANs), and multiplexer and private networks.

One of the most promising elements of the AMT 5003 is its potential for use with advanced systems considered part of the emerging multimedia field. For example, when used in conjunction with AMS 5000 systems, this product should prove especially useful in future cable television transmission using high-definition broadcasting technologies.

#### New I/O Connection Architecture Using Fiber-Optics Technology

43070202B Tokyo HITACHI TECHNOLOGY 94  
in English Jun 94 p 16

[Text] Large-scale computer system applications have increased in number and variety, and the quantity of data to be processed has grown rapidly. System configurations

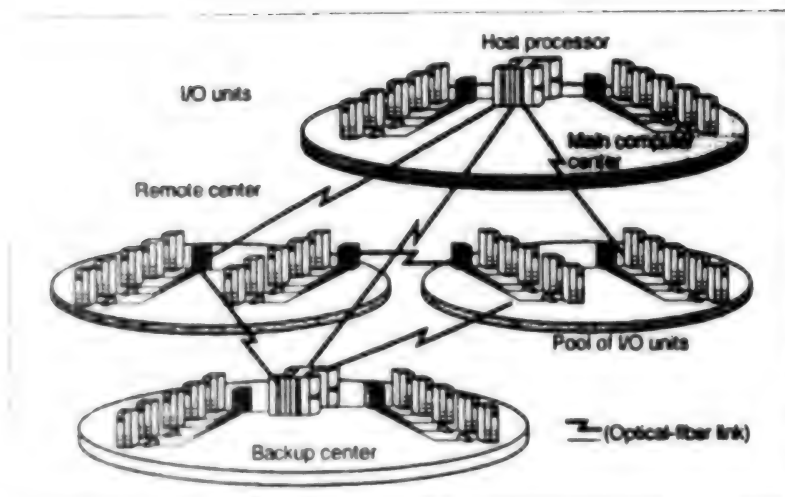
have become much more complex to keep up with these increased demands, and operation costs have escalated.

In addition, globalization of system applications has brought about a need for 24-hour-a-day operation. This has created requirements for improvements in the capability and flexibility of connecting the CPU and I/O units, such as remote extension with high-speed data transfer, dynamic I/O reconfiguration management, and large-scale file sharing.

Hitachi, Ltd. was the first Japanese firm to market optical-channel subsystem products using fiber-optics technology to meet these requirements. It has been making improvements to the optical-channel subsystem ever since. The new I/O connection system developed by Hitachi is called advanced connection architecture (ACONARC). It has more extensive functionality than the existing optical-channel subsystem and greatly improves I/O connectivity.

ACONARC is an I/O connection architecture corresponding to IBM's ESCON, (ESCON is a registered trademark of International Business Machines Corp.) and is supported by the HITACHI M-880 very large-scale general-purpose computer, high-end models of the Hitachi M-860 large-scale general-purpose computer, and the Hitachi S-3800 supercomputer. This architecture allows the CPU and I/O units to be up to 9 km apart and permits data transfer over an interface at the high speed of 17 Mbyte/s using fiber optics technology. It also introduces a new unit, "director," which switches optical signals at high speeds, allows easy reconfiguration of the I/O subsystem, and provides large-scale file sharing.





Concept of the Connection Between I/O Units and Centers Using the Advanced Connection Architecture. The advanced connection architecture's long-distance connectivity enables data processing centers and I/O units at remote locations to communicate with each other in an integrated manner.

#### ATM Switch/Multiplexer AMS5000 Meets International Needs for Broadband ISDN

43070202C Tokyo HITACHI TECHNOLOGY 94  
in English Jun 94 p 18

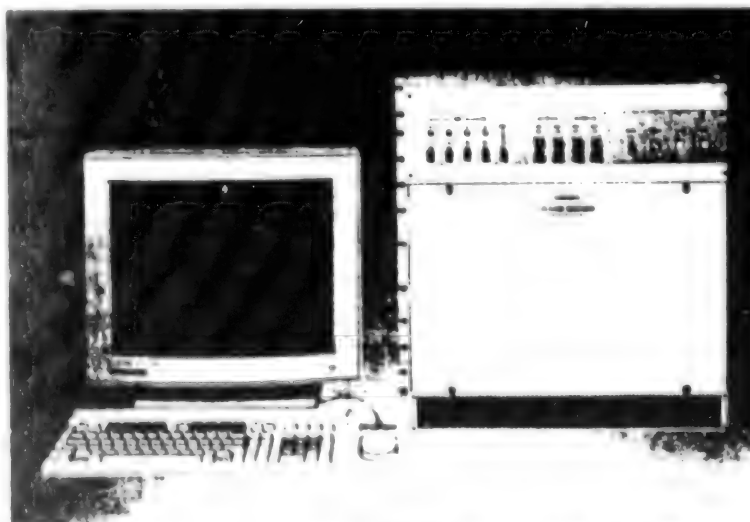
[Text] Hitachi, Ltd. has developed an asynchronous transfer mode (ATM) switch/multiplexer, AMS5000, for international broadband ISDN markets such as the U.S. It implements ATM cell multiplexing/demultiplexing and switching functions. The AMS5000 assists in the early introduction of an ATM network that provides high-speed communications services between computers and provides multimedia services for voice, data, and video.

Specifications of the AMS5000 include a throughput capacity of 600 Mbps. Line interfaces include DS-1 (1.5

Mbit/s) and DS-3 (45 Mbit/s) on the subscriber side and DS-3 and OC-3c (156 Mbit/s) on the network side. VPI/VCI capacity is up to 4,096 per line.

Traffic management functions provide four grades of service with peak-rate and average-rate policing. Network management function conforms to the standard LAN management protocol SNMP. The AMS5000 can support the multimode fiber interface and frame relay service by adding or replacing interface cards, or both.

The AMS5000 has been adopted as one of the key pieces of equipment for the first major test of digital-interactive CATV service in the U.S. It will be incorporated in the system for trial operation in Fall 1994.



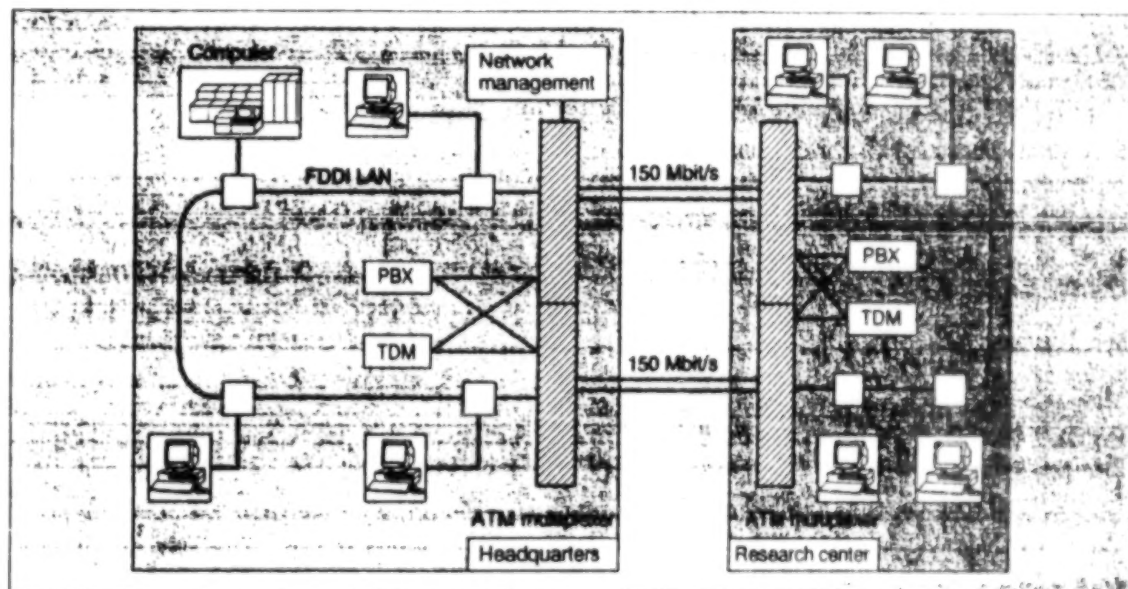
ATM Switch/Multiplexer AMS5000 and Its Local Craft PC

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**ATM Multiplexer for Integrated Network Structure**  
43070202D Tokyo HITACHI TECHNOLOGY 94  
in English Jun 94 p 19

[Text] Hitachi, Ltd. has developed an asynchronous transfer mode (ATM) multiplexer for the fiber distributed data interface (FDDI) repeater using ATM multiplexing technology. It is a new generation multiplexer that provides 150-Mbit/s digital-leased interfaces as trunk interfaces using the ATM multiplexing system.

The multiplexer provides both an FDDI repeater function and a connecting function for PBXs and TDMs. The repeater function integrates two separate FDDI LANs into one using 150-Mbit/s digital-leased lines. The connecting function integrates audio and data from each network by changing the signals of existing network equipment into cells. ATM multiplexers allow a network to be integrated easily by using ATM and contribute to the implementation of broadband-multimedia capabilities on private-communication networks.



Network Example Using ATM Multiplexers

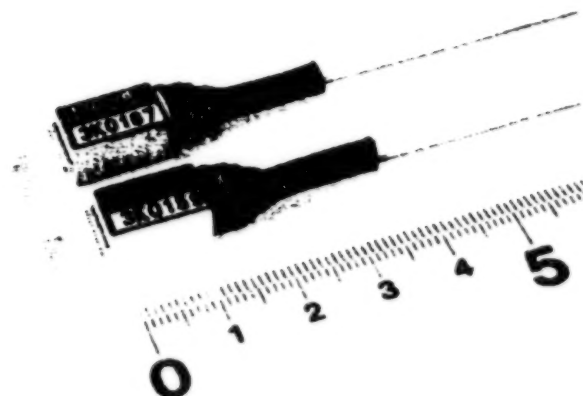
### Compact Low-Power Optical Interconnection Modules Provide High-Throughput Signal Transfer

43070202E Tokyo HITACHI TECHNOLOGY 94  
in English Jun 94 p 19

[Text] Optical interconnection is a key technology in the design of advanced information systems, such as large-capacity communication systems and massively parallel computers. It is compatible with the present electrical interconnection, providing higher-speed and higher-density interconnection between circuit boards. Optical interconnection will replace current coaxial cables with fiber cables, satisfying the requirement for accelerated LSI speed and higher circuit integration.

Hitachi, Ltd. has developed fully integrated compact 10-channel optical-interconnection modules: the MCS2101 transmitter and MCR2101 receiver. They can transmit 9-channel 200-Mbit/s data signals and a clock in parallel through a 400-m single-mode fiber array. Both modules have ECL interfaces and a 10-channel optical connector.

The MCS2101 includes a 10-channel laser array and a driver IC, while the MCR2101 includes a 10-channel photodiode array and a receiver IC. Each module measures 9mm W x 14mm L x 6mm H (0.8 cc); the total power consumption of a transmitter/receiver pair is 2 W, or 200 mW/ch, with a -3.3V single-voltage supply.



Transmitter and Receiver Modules for Optical Interconnection  
(Dimensions are in cm)

A fully dc-coupled error-free transmission scheme with simple circuits was developed by Hitachi to achieve compact low-power interconnection. Especially noteworthy is a newly developed 10-channel InGaAsP MQW monolithic integrated laser-diode array with the low threshold current of less than 3 mA. It is fabricated on a p-type InP substrate using only metal organic vapor phase epitaxy (MOVPE) processing. A planar-microlens (PML) array is used to obtain efficient optical coupling between the laser array and a fiber array.

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